Crop Water Use Data Available from the Southeastern USA

E. J. Sadler, C. R. Camp
AFFILIATE ASAE — MEMBER ASAE

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ABSTRACT

CROP water use data were extracted from literature data originating in the southeastern U.S. Data were catalogued according to location, method of measurement, crop, time, duration of study, form of data, main treatments, and concurrent data published. In all, 101 unique crop-experiment citations were located. The following locations, in four states, accounted for 56 of these: Pontiac, SC; Thorsby, AL; Ft. Lauderdale and Belle Glade, FL; and Raleigh and Waynesville, NC. Soil profile methods were used in 39; lysimeters were used in 44. The soil profile method of determining water use has been criticized for susceptibility to errors under high rainfall conditions common to the southeastern U.S. Experimental methods were not always completely described, so limitations of the data were not always clear. A few citations included discussions of the limitations; most common was lack of fetch or conditions non-representative to field crops. From the review, it can be concluded that a conclusive study is lacking in the physiographic area. It is also considered that insufficient data exist for a conclusive test of transferability of western irrigation management technology into the more humid Southeast.

INTRODUCTION

The purpose of this review was to collect the crop water use data originating from the southeastern U.S. into a regional characterization. This characterization had not been made previously for the Southeast. There was a general feeling among researchers that sufficient data for this purpose were not available. Adding to the lack of information was the suspicion that western-derived crop water use information may not be directly transferable to the humid Southeast without some local calibration. The research devoted to humid or subhumid area irrigation management and crop water use documents this suspicion (Allred and Chen, 1953; Blaney and Criddle, 1962; Decker, 1966; Mustonen and McGuinness, 1968; Parmele and McGuinness, 1974; Phene and Beale, 1976; Lambert, 1980; Hammond et al., 1981; Lambert et al., 1981; Gregory and Schottman, 1980, 1982; Boggess et al., 1983; Hook et al., 1984). Most crop water use information in use in the U.S. originated in the semi-arid or arid regions of the country, whereas the conditions in the Southeast are typically more humid. In addition, the high probability of occurrence of rainfall causes changes in the planning and operation of irrigation systems in the region. Further, solar irradiance is highly variable because of scattered convective cumulus clouds typical of summer afternoons. Finally, for irrigation in some regions of the Southeast, shallow or sandy surface soils may require water management that is different from that required in the West. These reasons prompted us to compile this review to aid in assessing the quantity and quality of crop water use information available in the region.

Van Bavel (1959b) listed five uses of knowledge about evapotranspiration (ET): evaluating drought occurrence, flooding, trafficability, current moisture status, and irrigation scheduling. Drought occurrence probabilities may be used in long-term planning and management decisions. Both trafficability and current moisture status may influence short-term management decisions such as scheduling of cultural practices; irrigation scheduling is one such example. Hydrologic uses of ET knowledge include forecasts of flooding potential and water storage. Seasonal and peak daily data are used in irrigation and drainage systems design and for resource development and planning. Data on a daily to weekly basis are used for irrigation scheduling and some crop simulation. Instantaneous rate data are used for theory and hypothesis testing and detailed crop simulation. See Jensen (1974) for additional discussion.

For this review, the emphasized use of the ET information is to contribute to water management models used in irrigation scheduling. Availability of low-cost computing power at the farm level has provided the means to use this information in decision-aid calculations and simulations. Evapotranspiration knowledge is not absolutely required for irrigation water management; several irrigation guides emphasize observation of soil or plant indicators. However, in order to schedule irrigation in advance using such indicators, the operator either must have accumulated sufficient experience to judge the rate of change of the indicator or must rely on guidelines that have been developed for his conditions. The knowledge embodied herein could be used, and in cases part of it has been used, in the preparation of such guidelines.

REVIEW METHODS

Literature included in the review originated from the Southern Atlantic Coastal Plain, part of the Gulf Coastal Plain, the Southern Piedmont, and the Lower Mississippi Valley. This area was chosen for similarities in solar irradiance, temperature, humidity, potential evapotranspiration (PET), and major soil types.

Terms that will be used in this review follow from the water balance of a field soil volume within which water is

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The authors are: E. J. SADLER, Soil Scientist, and C. R. CAMP, Agricultural Engineer, USDA-ARS, Coastal Plains Soil and Water Conservation Research Center, Florence, SC.

assumed to flow only vertically:

$$dS/dt = P + I - E - T - R - D \quad [1]$$

where
- S = the soil water content, mm
- t = time, s
- P = precipitation rate, mm/s
- I = irrigation rate, mm/s
- E = evaporation rate, mm/s
- T = surface runoff rate, mm/s
- R = transpiration rate, mm/s
- D = drainage rate, mm/s.

The terms R and D may be negative or positive, and in the case of condensation, so may E. The vertical extent of the soil volume is defined by the rooting depth. Integration of these terms over time results in time units of hours, days, weeks, 10-d periods (sometimes termed dekades), months, seasons, or years, with units of depth adjusted as desired to maintain reasonable values for the variables.

Crop water use will be used interchangeably with ET, or the sum of E and T from the equation above. If equation [1] were solved for E+T, changes in soil water content, runoff, and drainage would be lumped with precipitation and irrigation. One could readily see that "input water use", or precipitation plus irrigation (e.g., Rhoads et al., 1978) can equal ET only if the other three terms — runoff, drainage, and change in soil water content — are assumed to sum to zero.

The special case of ET from a well-watered crop that is evaporating at a rate primarily determined by climatic demand will be termed potential evapotranspiration or PET. Some discussion has been devoted to selecting standard crops, such as a well-watered short grass or alfalfa, and using the term reference crop ET (Jensen, 1974). Under that convention, PET would derive from theoretical considerations, and reference crop ET would be the expression of that theoretical rate through the characteristics of the crop and the surroundings chosen for the reference.

Data were extracted from the literature and catalogued in a microcomputer data base written for this purpose. Experiments were described by citation, location, map coordinates, measurement method, crop, seasons, data form, main treatments, and concurrent data reported. Measurement methods were catalogued according to the outline given in Table 1. The first three major categories were taken from Van Bavel (1961), corresponding to measurements on a field soil volume, on an enclosed volume, or on fluxes of vapor above the crop, respectively. The latter five were added for this review: hydrologic water balance, enclosed field chamber, simulation, evaporation pan measurement, and remote sensing. This last, in which ET is calculated from remotely sensed information (Hatfield, 1983; Stroosnijder et al., 1984) was represented once in the regional data base. The reader is referred to Raney (1955, 1959), Robins (1965), and Jensen (1965, 1974) for discussion of methods of measuring and estimating evapotranspiration, including accuracy of the methods and guidelines for avoiding sampling errors and biases.

Jensen (1974) outlined precautions that should be taken when using soil profile sampling methods. In particular, under conditions common to the Southeast, one should avoid methods that involve deep percolation and runoff. Imprecision in estimating these two terms in the soil water balance calculation directly affects the calculation of ET. In spite of problems under conditions of frequent rainfall, several citations report useful information obtained through soil profile sampling procedures.

Border and boundary effects for lysimeters are discussed by Jensen (1974). This discussion and the inherent precautions and restrictions can be applied to contained soil profile plots (e.g., Stansell et al., 1976) as well. Van Bavel et al. (1963) discussed the effects of the crop immediately surrounding the lysimeter. The first effect of no surrounding crop, or a short grass around a taller crop, is increased energy and mass transfer across the sides of the contained canopy, which causes greater evapotranspiration. Small border plots of the same crop or similar height crop may eliminate these horizontal transfers, yet fail to provide representative boundary conditions above the crop. Rosenberg et al. (1983), in a discussion of fetch requirements, gave a height of crop to fetch ratio of 1:100 as being sufficient for agricultural crops, although Mather (1959) stated that fetch requirements may be somewhat reduced under humid conditions. This latter requirement applies to all measurements of ET.

Many methods exist for the calculation or simulation

TABLE 1. CATEGORIES OF ET AND PET MEASUREMENT METHODS ENCOUNTERED IN REVIEWED LITERATURE. THE PRIMARY AND SECONDARY LABELS ARE CONCATENATED TO DESCRIBE THE METHOD. FOR EXAMPLE, PG IS SOIL PROFILE MEASUREMENT BY GRAVIMETRIC SAMPLING

Labels Pri	Sec	Descriptions
P		Soil profile methods
	G	Gravimetric samples
	M	Gamma attentuation
	N	Neutron probe
	R	Resistance blocks
	T	Tensiometers
L		Lysimeter methods
	C	Constant water table lysimeters
	P	Percolation lysimeters
	W	Weighing lysimeters
	WH	Hydraulic pillow lysimeters
V		Vapor flux measurements
	A	Aerodynamic profile
	C	Combination
	EB	Energy balance
	EC	Eddy correlation
H		Hydrologic water balance
EC		Enclosed field chamber
S		Simulation
	BC	Blaney and Criddle (1952,1962); USDA-SCS (1967)
	BCx,y	BC by Shih et al. (1977); Smajstrla et al. (1984)
	BN	Bartholic et al. (1970)
	C	Christiansen (1968)
	G	Grassi* (1964)
	H	Hamon (1961)
	JH	Jensen and Haise (1963); Jensen (1974)
	La	USWB Lake simulation (Kohler et al., 1955)
	Mk	Makkink (1957)
	MM	Mustonen and McGuinness (1968)
	P	Penman (1948); Doorenbos and Pruitt (1977)
	Pa	USWB Class A pan simulation (Kohler et al., 1955)
	Pk	Papadakis (1965)
	PT	Priestly and Taylor (1972)
	Ra,n	Radiation equivalent: solar, net
	SS	Stephens and Stewart (1963)
	T	Thornthwaite (1948)
	Tu	Turc (1961)
	VB	Van Bavel (1966)
M		Evaporation pan measurements
	A	Single site pan data (-S, screened; -Q, square)
	AC	USWB Class A pan network
Re		Remote sensing

*Grassi, C. J. 1964. Estimation of evapotranspiration from climatic formulas. M.S. Thesis, Utah State Univ., Logan, Utah.

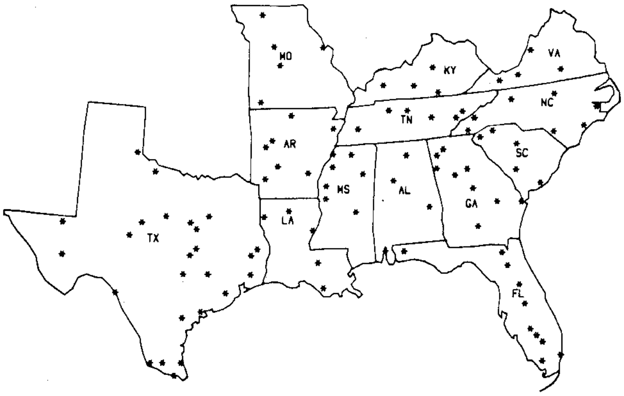

Fig. 1—U.S. Weather Bureau reporting stations for evaporation pans. (USDC-NESDIS-NCDC, 1978).

of PET. Within general methods, researchers use varying forms and coefficients. The evolution of the combination method is a good example, starting with the original Penman (1948) formula and progressing through that of Doorenbos and Pruitt (1977) in this review. The specific form used in a particular citation is reported here in order to document the data as fully as possible.

RESULTS AND DISCUSSION

The reported crop water use information varied according to method used, temporal resolution, and method of presentation. These considerations together define the quality of the ET information. Because of differences in research objectives of both the reported research and those interested in using the information in this review, the citations are reported without judgement. The overall conclusions of this review contain the authors' judgements of the data reported. It is left to the reader to determine suitability of data contained in individual citations.

Regional Coverage

Those results with regional coverage are discussed first. The most comprehensive area coverage by empirical PET information is available from the USWB Class A evaporation pan network. Locations reporting pan evaporation (Fig. 1) were extracted from the USWB maps of participating stations published monthly by state in the Climatological Data and Hourly Precipitation Data series (USDC, NESDIS, NCDC). These evaporation data are in the Climatological Data series and are also available on magnetic tape as part of the standard record. Additionally, the pan record up to 1980 has been consolidated into three tapes and can be obtained at lesser cost but without supporting air temperatures and other parameters (G. W. Goodge, USDC, NESDIC, NCDC, personal communication, 1985).

Data from the pan network for the contiguous 48 states were published in 1959 in summary form by the Weather Bureau of the Department of Commerce (Kohler et al. 1959). They presented pan and lake evaporation, coefficients for conversion, and supplementary graphs and tables. Farnsworth et al. (1982) presented similar data. Woolhiser and Wallace (1984) mapped average daily pan evaporation for the states east of the Rocky Mountains. They presented a method of summarizing those data using harmonic analysis.

In 1948, two publications presented methods by which PET could be calculated from climatic data. Thornthwaite (1948) presented his method as part of his climatic classification, which included a PET map for the 48 contiguous United States. Potential evapotranspiration depended upon station location and climatic normals of air temperature. Penman (1948) presented a formula derived from a combination of energy balance and mass transport considerations by which evaporation from open water could be calculated from net radiation, soil heat flux, air vapor pressure deficit, and windspeed.

C. H. M. van Bavel of the USDA-ARS and researchers from several southern state experiment stations cooperated on a series of publications in which Penman's (1948) equation was used with a coefficient of 0.7 to represent a short, well-watered crop (See Van Bavel (1953, 1956) for methods). They used long-term normals of temperature, humidity, and solar radiation from several first-order stations to estimate PET and used rainfall records and a soil water balance to estimate agricultural drought probabilities. To account for soil water storage variability, they presented results for a range of soil profile storage capacities. These analyses were completed first for North Carolina (Van Bavel and Verlinden, 1956), and eventually for Virginia (Van Bavel and Lilliard, 1957), South Carolina (Van Bavel et al., 1957), Georgia (Van Bavel and Carreker, 1957), and Alabama (Ward et al., 1959). The Lower Mississippi Valley was considered as a whole, including Louisiana, Mississippi, Arkansas, western Tennessee, extreme southeastern Missouri, and western Kentucky (Van Bavel, 1959c). The series was summarized by Van Bavel (1959a). In that report, he referenced Knetsch and Smallshaw (1958), in which Tennessee was covered as an individual state. April to September seasonal PET isolines, as calculated using Penman's equation and given in the summary, are also shown in Fig. 2.

A recent USDA-ARS regional cooperative project is now being prepared for publication (Camp and Campbell, 1986). This corn irrigation scheduling study included irrigation application using tensiometers, irrigated scheduling using a computer-based water balance procedure (Lambert, 1980; Lambert et al., 1981), and a nonirrigated control. Locations

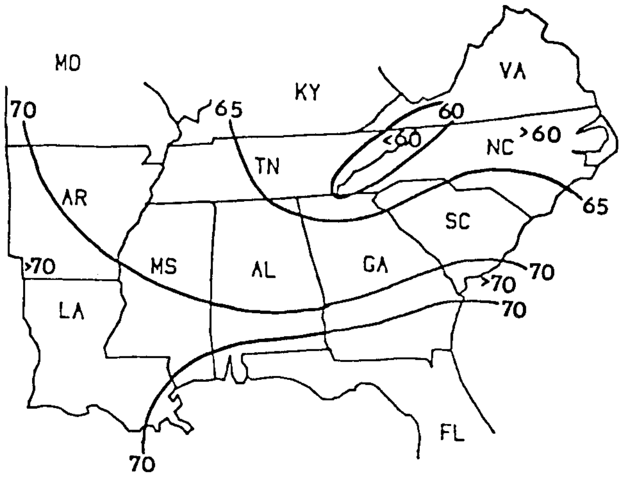

Fig. 2—Seasonal (April through September) values of evapotranspiration in centimeters as computed with the Penman formula. (Van Bavel, 1959a).

participating in the study included Raleigh, NC (Cassel et al., 1985; Cassel and Edwards, 1985), Florence, SC (Camp et al., 1984), Blackville, SC, Tifton, GA (Hook et al., 1984), and Gainesville, FL. Researchers at Suffolk, VA (Powell et al., 1981), were conducting independent but similar research with the same corn hybrid but were using a different scheduling program. A section describing that work is included in the ARS project report. As part of the regional project's scheduling program, PET and ET were calculated using the Jensen-Haise method. Periodic gravimetric soil samples were used to adjust inaccuracies in the process. Seasonal patterns of crop water use should be made available from this project. The similarities of methods, crop, soils, and reporting across locations will make this ET information valuable.

State-wide Coverage

Several reports characterize PET on a state-wide basis. Grissom et al. (1955) presented PET simulated using an air-temperature-based method for eight locations in Mississippi. For the five experiment stations in South Carolina, Kish (1967) presented normal daily PET, calculated using Thornthwaite (1948). Rogers and Bartholic (1975) used the Blaney-Criddle method to simulate monthly citrus water use requirements for 10 Florida locations. A state-wide summary of ET research was made by researchers in Florida (Jones et al., 1984). They described ET theory and results from, apparently, all known ET research conducted in Florida. Methods reported lysimetry, soil profile sampling, hydrologic balance, and energy balance-vapor flux methods. They also made comparisons among methods where possible and synthesized additional data by simulation and by generating crop coefficients from actual ET and PET. They included some data taken in Alabama (Doss et al.,

TABLE 3. ABBREVIATIONS USED IN MAIN TREATMENTS AND CONCURRENT DATA FIELDS IN TABLES 2,4,5 AND 6

( ) Means 'as a function of', e.g., IRR(SW) means irrigation as a function of SW.

$	Economic yield
%S	Percent sunshine
CaRD	Controlled and Reversible Drainage
CBWB	Computer-based water balance
CER	CO2 exchange rate
CV	Cultivar
D	Drainage
Dens	Density of crop
DM	Dry matter
G	Soil heat flux
H	Humidity
HF	Sensible heat flux to air
Ht	Crop Height
J+84 Fn	See Jones et al. (1984), fig. n.
K	Potassium
KC,Kc_p,KcR	Crop coefficient: ET/PET, ET/Pan, ET/SRa
LAI	Leaf area index
LDR	Leaf diffusion resistance
LWP	Leaf water potential
Mx	Measurement method
N	Nitrogen
Norms	Normals of previous parameters
P( )	Probability of ( )
PAR	Photosynthetically-active radiation
PD	Planting date
Phn	Phenology
Pop	Population
Q	Quality
Ra,n	Radiation, a = solar, n = net
RD	Rooting depth
RI	Rain and irrigation, also separately as R or I
Rnorm	Normal rainfall
Ro	Runoff
RP	Resistance of plant to water flow
RS	Row spacing
RWC	Relative water content
Sens	Sensor
SimCom	Simulation comparison
SW	Soil water content or potential (also AW)
t	Time during season
T	Air temperature
Tc	Temperature of crop
Td	Dew point temperature
Tens	Tensiometers
W	Wind speed or run
WTD	Water table depth
Y	Yield

TABLE 2. SUMMARY OF SOIL-PROFILE-DERIVED ET DATA. FOR EXPLANATIONS OF ABBREVIATIONS, SEE TABLES 1 AND 3

Reference	YR	St	Location	Mth	Crop	Seasons	Form	Main treatment	Concurrent data
Banks, et al.	85	GA	Athens	PN	Soybeans	82	Weekly	TillxSicklepod	SP,Ta,H,Ra,R,I,W,MPa
Carreker	63	GA	Watkinsville	PG	Cotton	54-57	Weekly	SimCom,Irr(AW)	ST,SH,SRa,KC
Doss & Thurlow	74	AL	Thorsby	PG	Soybeans	68-70	3-5d	Irr(AW)xRSxCV	Y,RI,Ht
Doss, et al.	65	AL	Thorsby	PG	Alfalfa	58-62,4	3-5d av	Irr(AW)	R,MA,T,Rn,KCp
Doss, et al.	65	AL	Thorsby	PG	Bahiagrass	57-58	3-5d av	Irr(AW)	R,MA,T,Rn;J+84 KC F10b
Doss, et al.	65	AL	Thorsby	PG	Canary gr	56-57	3-5d av	Irr(AW)	R,MA,T,Rn;J+84 KC F10b
Doss, et al.	65	AL	Thorsby	PG	Cm berm gr	57-58	3-5d av	Irr(AW)	R,MA,T,Rn;J+84 KC F10b
Doss, et al.	65	AL	Thorsby	PG	Coas b gr	57-62,4	3-5d av	Irr(AW)	R,MA,T,Rn,KCp
Doss, et al.	65	AL	Thorsby	PG	Cotton	58-59	3-5d av	Irr(AW)	R,MA,T,Rn,KCp
Doss, et al.	65	AL	Thorsby	PG	Fescue gr	56-57	3-5d av	Irr(AW)	R,MA,T,Rn,KCp
Doss, et al.	65	AL	Thorsby	PG	Ladino clv	56-57	3-5d av	Irr(AW)	R,MA,T,Rn
Doss, et al.	65	AL	Thorsby	PG	Lespedeza	57-58	3-5d av	Irr(AW)	R,MA,T,Rn
Doss, et al.	65	AL	Thorsby	PG	Orchrd gr	56-57	3-5d av	Irr(AW)	R,MA,T,Rn
Doss, et al.	65	AL	Thorsby	PG	Red clover	56-57	3-5d av	Irr(AW)	R,MA,T,Rn
Doss, et al.	65	AL	Thorsby	PG	Sart Sorg	57-61,4	3-5d av	Irr(AW)	R,MA,T,Rn
Doss, et al. a	62	AL	Thorsby	PG	Corn	57-60	3-5d g		R,I,Rnorm,KCp;KC=J+84 F11
Doss, et al. b	62	AL	Thorsby	PG	Dallis gr	55-58	Annual	Irr(AW)	Y,R,I
Doty	80	SC	Florence	PT	Corn	75-78	Weekly		MA,SCS,KC
Doty & Reicosky	78	SC	Florence	PT	Millet	70	Annual	Tillage	MA
Doty & Reicosky	78	SC	Florence	PT	Sweet Corn	72-73	Annual	Tillage	MA,Y,DM
England & Lesesne	62	NC	Waynesville	PR	Lespedeza	57	Monthly		ET(depth)
England & Lesesne	62	NC	Waynesville	PR	Pasture	56-57	Monthly		ET(depth)
England & Lesesne	62	NC	Waynesville	PR	Wheat	56-57	Monthly		ET(depth)
Geddes, et al.	79	AR	Fayetteville	PT	Soybeans	75-76	Monthly	Cockleburs	R,T,SP,DM,LAI
Land & Carreker	53	GA	Athens	PG	Corn	52	Weekly	Irr	R,I,SW,Y,DM
Land & Carreker	53	GA	Athens	PG	Cotton	52	Weekly	Irr	R,I,SW,Y,DM
Land & Carreker	53	GA	Athens	PG	Pole beans	52	Weekly	Irr	R,I,SW,Y,DM
Land & Carreker	53	GA	Athens	PG	Tomatoes	52	Weekly	Irr	I,R,SW,Y
Martin, et al.	79	SC	Pendleton	PTG	Soybeans	79	Weekly	Mx	MA,MAQ,MAS,ST
McWhorter & Bruce	63	MS	State College	PG	Cotton	58-59	3-5d		MA,Ra,Atmometer
Pallas, et al.	79	GA	Tifton	PR	Peanut	76	Seasona	Irr(t)	LWP,LDR,Y,Q
Reicosky, et al.	77	SC	Florence	PT	Millet	70	2-week		MA,SVB,R,I,D
Sanford & Hairston	84	MS	Miss. State	PN	Wheat	75-77	7-10d a	NxAntec. crop	Y,N,R,DM,H
Saxena, et al.	71	FL	Live Oak	P?	Tomatoes	69	3-5d g		J+84 F8
Stansel & Smittle	80	GA	Tifton	PR	Snap bean	75,76,78	3-5d (1	Irr(SW,Phn)xCV	MA,KCp,SW,I,Y,$
Stansel, et al.	76	GA	Tifton	PR	Peanut	70-73	3-5d (1	Irr(SW,Phn)xCV	J+84 F9;Y,Q,SW
Thornton	61	GA	Watkinsville	PG	Cotton	52-56	Seasona	Irr(SW)	Y
Van Bavel, et al.	84	TX	College St.	PNM	Grain sorg	82	3-7d	WATBAL Model	Ra,T,Td,W,LAI,RD,R,DM,SW
Weaver & Pearson	56	AL	Auburn	PG	Sudangrass	52,1 mon	Weekly	IrrxPopxN	R,I,SW,DM,T,H,W,MA,SBC,ST,SP

1962a, 1965), Georgia (Stansell et al., 1976), and South Carolina (Allison et al., 1958) because of their pertinence to research in northern Florida.

The pan data record for the Georgia Coastal Plain Experiment Station was examined, edited, and published as a state bulletin by Sheridan et al. (1974). Evaporation pan data are included in annual climatic summaries published as state bulletins for several states (e.g. Kish (1977) in South Carolina).

Soil Profile Sampling Method

The balance of the research was conducted at single sites, with no attempt at regionalization other than through literature citations. The first such method discussed here is the soil profile sampling method. Details of these ET data are summarized in Table 2. For definitions of abbreviations used, see Tables 1 and 3. The most comprehensive such work was reported by Doss et al. (1965) at Thorsby, AL. The most commonly reported profile method was gravimetric sampling. Others included tensiometer arrays, neutron methods, gamma attenuation, and resistance blocks.

Lysimetry

The earliest known lysimeter experiment in the region was conducted from 1933 to 1947 at the Sandhills Experiment Station at Pontiac, SC, near Columbia (Allison et al., 1958). Lysimetry came into greater use during the late 1950's and 1960's, with installations at Waynesville and Raleigh, NC, and Ft. Lauderdale and Belle Glade, FL. Ritchie and Burnett (1968) described a weighing lysimeter installed at Temple, TX, in 1966. Lysimeter data are summarized in Table 4. Lysimeters have recently been reported at two locations on the western edge of the region. Dugas et al. (1985) described the installation and design of a new weighing lysimeter at Temple, TX. Clark et al. (1984) described a 12-lysimeter installation at College Station, TX.

Vapor Flux Measurements

Only a few measurements of ET by vapor flux methods in the region were located. Allen et al. (1978) gave a single energy budget for a short grass pasture near Okeechobee, FL. Allen et al. (1980) gave hourly Bowen ratio ET for 10 days and daily for 17 days at a site near Okeechobee, FL. That study explored the potential for ET estimation from remote sensing methods and also had field chamber and soil profile data. Heimburg et al. (1982) gave hourly Bowen ratio ET for 42 days at Gainesville, FL, and included a method to calculate ET from average temperature gradient relationships. Extensive energy balance measurements were made in Temple, TX, as part of a lysimeter experiment with cotton and sorghum (Ritchie, 1971; Ritchie and Burnett,

TABLE 4. LYSIMETER-DERIVED ET DATA

Reference	YR	St	Location	Mth	Crop	Seasons	Form	Main treatment	Concurrent data
Allison, et al.	58	SC	Pontiac	LP	Corn	33-45,2	Yearly		R,Y
Allison, et al.	58	SC	Pontiac	LP	Cotton	33-45,7	Yearly		R,Y
Allison, et al.	58	SC	Pontiac	LP	Crotolaria	33-45,5	Yearly		R,Y
Allison, et al.	58	SC	Pontiac	LP	Millet	33-45,8	Yearly		R,Y
Allison, et al.	58	SC	Pontiac	LP	Oats	33-45,6	Yearly		R,Y
Allison, et al.	58	SC	Pontiac	LP	Peas	33-45,6	Yearly		R,Y
Allison, et al.	58	SC	Pontiac	LP	Peas+vetch	33-45,6	Yearly		R,Y
Allison, et al.	58	SC	Pontiac	LP	Rye	33-45,11	Yearly		R,Y
Allison, et al.	58	SC	Pontiac	LP	Rye+vetch	33-45,6	Yearly		R,Y
Allison, et al.	58	SC	Pontiac	LP	Ryotbrvt	33-45,5	Yearly		R,Y
Allison, et al.	58	SC	Pontiac	LP	Soybeans	33-45,4	Yearly		R,Y
Allison, et al.	58	SC	Pontiac	LP	Velvet bns	33-45,2	Yearly		R,Y
Allison, et al.	58	SC	Pontiac	LP	Vetch	33-45,6	Yearly		R,Y
Allison, et al.	58	SC	Pontiac	LP	Cowpeas	33-45,2	Yearly		R,Y
England	63	NC	Waynesville	LW	Alfalfa	61	Hourly,		Day/night, R
England	63	NC	Waynesville	LW	Alfalfa	61	Monthly		Day/night,R
England	63	NC	Waynesville	LW	Oats	60	Monthly		Day/night,R
England	63	NC	Waynesville	LW	Pasture	58	Monthly		Day/night,R
England & Lesesne	62	NC	Waynesville	LW	Corn	59	Monthly		Day/night
Hatfield, et al.	84	TX	Temple	LW	Grain sorg	80	Hourly,		SBN,VEB,SP
Heatherly, et al.	80	MS	Stoneville	LW	Cotton	78	Weekly		SW,R
Heatherly, et al.	80	MS	Stoneville	LW	Soybeans	78	Weekly		SW,R
Howell & Hiler	75	TX	College Sta.	LP	Sorghum	73	3-5d c	Irr(LP,Phn)	MA,SP,SVB,SRn
Parmele & McGuinness	74	OH	Coshocton	LW	Corn	69	Seasona	SimCom	SLa,SPa,SBC,SJH,SC
Parmele & McGuinness	74	OH	Coshocton	LW	Grass	68	Seasona	SimCom	SMM,SRn,SP,SVB
Reikerk	85	FL	Gainesville	LW	Pine	81-82	Daily g		
Reikerk	85	FL	Gainesville	LW	Pine	81-84	Monthly		SP,Kc
Ritchie	71	TX	Temple	LW	Cotton	68	5-d av		Rn,HF,G,Ra,H,T,W
Ritchie	71	TX	Temple	LW	Sorghum	69	5-d av		Rn,HF,G,Ra,H,T,W
Ritchie	73	TX	Temple	LW	Corn	72	Daily	Irr	SP,SW,LDR,LWP,LAI
Ritchie	73	TX	Temple	LW	Corn	72,1d	Hourly		SP,LWP,LDR
Ritchie, et al.	72	TX	Temple	LW	Sorghum	69,2d	Hourly	Drought	SW,SP
Shih	83	FL	Belle Glade	LC	Sw corn	80,82	Weekly	WTD	KCp,Y
Shih	84	FL	Belle Glade	LC	Sw sorghum	81-82	Weekly	WTD	KCp,Y
Shih & Gascho	80	FL	Belle Glade	LC	Sugarcane	77-79	Monthly	WTD	Y
Shih & Rahi	84	FL	Belle Glade	LC	Lettuce	80-81	Weekly	WTD	KCp,Y
Shih & Snyder a	84	FL	Belle Glade	LC	Taro	81-82	Monthly	Flooding	MA,T,R,Ra,Tl
Shih & Snyder b	84	FL	Belle Glade	LC	Pasture	82-83	Monthly	WTD	KCp,MA
Shih, et al.	83	FL	Belle Glade	LC	Rice	80	2-week	Planting mthd.	KCp,LAI
Shih, et al. a	82	FL	Belle Glade	LC	Taro	80-81	Weekly	Flooding	MA
Stephens & Stewart	63	FL	Ft. Lauderdale	LC	St.Aug gr	57-59	Monthly	SimCom,WTD	MA,Ra
Stewart & Mills	67	FL	Ft. Lauderdale	LC	Pasture	58-64,5	Monthly	WTDxDens	J+84 T9,F10b;MA,Ra
Stewart, et al.	69	FL	Ft. Lauderdale	LC	Berm. gr	65-67	Yearly	WTDxDens	MA,R
Van Bavel	61	NC	Raleigh	LP	Grasses	56-58	Monthly		
Van Bavel	61	NC	Waynesville	LP	Grasses	52-55	Monthly		
Van Bavel	61	NJ	Seabrook	LC	Leg/gr	50-53	Monthly		
Van Bavel	61	OH	Coshocton	LW	Leg/gr	44-55	Monthly		
Van Bavel & Harris	62	NC	Raleigh	LP	Berm grass	56-58	Weekly		SP,SRn,SPn
Van Bavel & Harris	62	NC	Raleigh	LP	Corn	57-58	Weekly		SP,SRn,SPn
Weaver & Stephens	63	FL	Ft. Lauderdale	LC	Bell peppr	54-55	Seasona		MA,DM
Williamson & Carreker	70	NC	Raleigh	LC	Corn	61	Weekly	WTD	R
Williamson & Carreker	70	NC	Raleigh	LC	Millet	63	Weekly	WTD	R
Williamson & Carreker	70	NC	Raleigh	LC	Sorghum	61	Weekly	WTD	R
Williamson & Carreker	70	NC	Raleigh	LC	Soybeans	60	Weekly	WTD	R

TABLE 5. HYDROLOGIC WATER BALANCE ET DATA

Reference	YR	St	Location	Mth	Crop	Seasons	Form	Main treatment	Concurrent data
Allen, et al.	82	FL	Indian R. Fm W1	H	Mixed	59-72	Yearly		R,Ro
Allen, et al.	82	FL	Monreve Rch W4	H	Mixed	67-73,5	Monthly		MA
Allen, et al.	82	FL	Monreve Rch W4	H	Mixed	67-73,5	Yearly		MA,R,Ro
Allen, et al.	82	FL	Up Taylor Cr W2	H	Mixed	59-73	Yearly		MA,R,Ro
Grubb & Rutledge	79	FL	Green Swamp	H	Mixed	Unknown	Yearly		
Knisel, et al.	85	FL	Taylor Cr W3	H	Mixed	59-73	Yearly		MA;J+84 T5
Knisel, et al.	85	FL	Taylor Cr W5	H	Mixed	65-72	Yearly		MA;J+84 T5
Koo & Sites	55	FL	Lake Alfred	H	Citrus	Unknown	Monthly		J+84 T9
Mierau	74	FL	Belle Glade	H	Mixed	62-71	Monthly		MA,R,D
Phung & Bartholic	76	FL	Gainesville	H	Peaches	73	Monthly		J+84 T9
Rogers, et al.	83	FL	Ft. Pierce	H	Citrus	73-81	Monthly	SimCom,Tillage	MA,SBC,SJH,SP,MA*K;J+84 F10a
Shih, et al.	81	FL	Belle Glade	H	PET	Normals	Monthly	SimCom,Mierau	SBC,SBx,SP,ST,MA,Ra,T,H,W
USGS	84	FL	Osc Co Jane Gre	H	Mixed	Unknown	Yearly		
USGS	84	FL	Osceola Co S65	H	Mixed	Unknown	Yearly		
USGS	84	FL	Osceola Co Wolf	H	Mixed	Unknown	Yearly		
Williams	83	GA	Little River WS	H	Mixed	68-81	Yearly		SBC use coeff

1971; Ritchie and Jordan, 1972; Ritchie et al., 1972).

Field Chamber Measurements

The portable field chamber technique was described by Reicosky and Peters (1977), Boote et al. (1980), and Reicosky (1981). Reicosky and Deaton (1979) presented hourly ET data for 2 days, two soybean cultivars, and two water regimes during drought in Florence, SC. Jones et al. (1982, 1983) and Zur et al. (1982, 1983) collectively presented ten diurnal patterns of portable-field-chamber-derived soybean ET data from Gainesville, FL. These data are given as part of a validation of a water relations model and are supported by carbon flux and physiological measurements as well. Peacock and Dudek (1984) used the portable chamber to study the physiological response of St. Augustinegrass swards to irrigation timing in Gainesville, FL. They presented no time-dependent data; ET was plotted as a function of interval between irrigations.

Hydrologic Water Balance Data

The calculation of ET through the hydrologic water balance provides wider-scale, longer-term estimates than those available from other methods of measurement. These data, as mentioned above, are needed for the hydrologic problems of flooding and water supply. The citations located in this review originated in Florida and south Georgia (Table 5).

Simulation Methods

Simulation of PET or ET has become an effective source of information for cases in which direct measurement is neither practicable nor affordable. Simulation-based information was found in four general groups of citations based upon the objective of the research: climatic classification, comparison of simulation methods, theoretical studies, and as reference values to document field research. Examples of the former three will be given below; the last one was discussed above with the field experiments.

Simulation for the purpose of characterizing climate generally results in information applicable to a region and was discussed above in the section on regional works. The effort by Thornthwaite (1948) was a classic example. The 1950's USDA-ARS series by Van Bavel and co-workers used Penman's (1948) methods and a soil-water accounting procedure to characterize agricultural drought. Nine citations report comparisons of two or more simulation methods. These are listed in Table 6.

For the convenience of the reader, the authors suggest the extensive comparisons made between lysimeter ET and several simulation methods by an ASCE committee (Jensen, 1974). Although no data are given for the Southeast region proper, the methods are well documented, and the comparison and results provide a reference with which to compare or contrast southeast data.

The final category of simulation was that of systems in which measurement was not practicable because of limitations of experimental materials, labor, capital, or time. One clear example was a 13-yr analysis of water budget and erosion potential for a sycamore biomass farm (Crandall and Luxmoore, 1982). Other examples include crop models that emphasize water relations such as the soybean model of Jones et al. (1982, 1983) and Zur et al. (1982, 1983), and the sorghum model tested by Van Bavel et al. (1984). Models have been used in economic analyses by Allen and Lambert (1971a, 1971b) and Boggess et al. (1981, 1983). Models used for irrigation management in the region have been reported by Rochester and Busch (1972), Jones and Smajstrla (1979), Lambert (1980), Lambert et al. (1981), Swaney et al. (1982), Hayes et al. (1983), and Brown and Hayes (1984). Finally, South Carolina corn microclimate and water potential data reported by Reicosky et al. (1975) was

TABLE 6. SIMULATION OF PET OR ET FOR THE PURPOSE OF COMPARISONS OF SIMULATION METHODS

Reference	YR	St	Location	Mth	Crop	Seasons	Form	Main treatment	Concurrent data
Carreker	63	GA	Watkinsville	PG	Cotton	54-57	Weekly	SimCom,Irr(AW)	ST,SH,SRa,KC
Jones, et al.	84	FL	Belle Glade	MA	Pan	62-71	Monthly	SimCom,Mierau,	SBC,SBx,SP,SSS,ST
Jones, et al.	84	FL	Hialeah	SP	PET,Pan	Normals	Monthly	SimCom	Table 3
Jones, et al.	84	FL	Lakeland	SP	PET,Pan	Normals	Monthly	SimCom	Table 3
Jones, et al.	84	FL	Milton	SP	PET,Pan	Normals	Monthly	SimCom	Table 3
McCloud	55	FL	Gainesville	MTA	Bahia g	53-54	Monthly	SimCom	R,D
Parmele & McGuinness	74	OH	Coshocton	LW	Corn	69	Seasona	SimCom	SLa,SPa,SBC,SJH,SC
Parmele & McGuinness	74	OH	Coshocton	LW	Grass	68	Seasona	SimCom	SMM,SRn,SP,SVB
Rogers, et al.	83	FL	Ft. Pierce	H	Citrus	73-81	Monthly	SimCom,Tillage	MA,SBC,SJH,SP,MA*K;J+84 F10a
Shih, et al.	81	FL	Belle Glade	H	PET	Normals	Monthly	SimCom,Mierau	SBC,SBx,SP,ST,MA,Ra,T,H,W
Smajstrla, et al.	84	FL	Orlando	SP	PET	Normals	Monthly	SimCom	SJH,SSS,ST,SBx,SBy,SBC,SRa
Stephens & Stewart	63	FL	Ft. Lauderdale	LC	St.Aug gr	57-59	Monthly	SimCom,WTD	MA,Ra
Van Bavel & Wilson	52	NC	Chapel Hill	MA	PET	Normals	Monthly	SimCom	SP,ST,SBC(Raleigh)

TABLE 7. SUMMARY OF GEOGRAPHIC COVERAGE, CROPS, TEMPORAL RESOLUTION, AND NUMBERS OF EXPERIMENTS IN REVIEW

State	Crop->Corn Time->hdwms	Wheat hdwms	Soybn hdwms	Cottn hdwms	Srghm hdwms	Grain hdwms	Grass hdwms	Legum hdwms	Veget hdwms	Peant hdwms	Sum over crops h	 d	 w	 m	 s	Total by State
Alabama	--1--	-----	--1--	--1--	-----	-----	--8-1	--4--	-----	-----	0	0	15	0	1	16
Arkansas	-----	-----	---1-	-----	-----	-----	-----	-----	-----	-----	0	0	0	1	0	1
Georgia	--1--	-----	--1--	--2-1	-----	-----	-----	-----	--3--	--1-1	0	0	8	0	2	10
Florida	--1--	-----	3----	-----	-----	--1--	51131	-----	--1-1	-----	8	1	4	3	2	18
Louisiana	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0	0	0	0	0	0
Mississippi	-----	--1--	--1--	--2--	-----	-----	-----	-----	-----	-----	0	0	4	0	0	4
North Carolina	--21-	---1-	--1--	-----	--1--	--11-	--14-	1--2-	-----	-----	1	0	6	9	0	16
South Carolina	--1-2	-----	1-1-1	----1	-----	--1-5	-----	----5	----1	-----	1	0	3	0	15	19
Texas	11---	-----	-----	--2--	3-4--	-----	-----	-----	-----	-----	4	1	6	0	0	11
Virginia	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0	0	0	0	0	0
Sum over states							1									
(Read down)	11612	--11-	4-511	--7-2	3-5--	--315	51072	1-425	--4-2	--1-1						
Crop totals	11	2	11	9	8	9	25	12	6	2	14	2	46	13	20	95

Example: For grasses, weekly data exists for eight experiments in Alabama and one each in Florida and North Carolina, providing a total of 10.

used by Choudhury and Federer (1983), and Lambert and Reicosky (1984) in model tests.

SUMMARY AND CONCLUSIONS

A comprehensive review of southeastern U.S. regional crop water use data was compiled. The objective of the review was to catalogue existing ET information in order that conclusions could be reached regarding sufficiency of that information for research and application in water management. The region covered, roughly, the Atlantic and Gulf coasts from Virginia to east Texas, plus the lower Mississippi Valley. This region was chosen for similarities in climate, including radiation, temperature, humidity, rainfall, and PET. In general, the region has more rainfall and higher humidity than the Midwest and West, which is the origin of most ET information in the U.S. The concern is whether this western information is directly transferable into the more humid Southeast. The information in this review can guide research to answer that question.

Table 7 is a summary of the geographic coverage, crops studied, temporal resolution of the empirical crop water use data, and numbers of citations in each of these three categories. This presentation given equal weight to each reference, even though the studies ranged in length from a few days to several years. The reports did not always present numbers of replications, and the data are often averaged over years, so reporting number of crop-years did not appear to be preferable over number of citations. The total, 95, excludes six crop-experiments for which no matching crop category existed: taro, sugarcane, pine forest, and heterogenous mixtures.

It is apparent that few reports exist of crop water use with hourly or even with daily resolution. The majority of the data (77%) was obtained with gravimetric or other soil profile sampling or with either percolation or constant-water-table lysimeters. These data normally were averages over 3 to 5 days, such that daily ET comparisons to these data are limited to that resolution.

Weighing lysimeter data for field crops within the region are limited to monthly ET for one year each of cotton and soybean (England, 1963) and weekly ET for 1 year each of cotton and soybean (Heatherly et al., 1980). The latter was judged adequate only for comparison of relative rates by the researchers because both lysimeters were small and may have had unrepresentative surface area per unit of row.

Excluding the work peripheral to the region in Ohio and New Jersey that was added for comparison, ET data from 101 unique crop-experiments were cited. These exclude multiple references utilizing data from the same experiments. Fifteen of these were seasonal data from percolation lysimeter experiments with suspect fetch (Allison et al., 1958). Fifteen were gravimetric soil sampling experiments of Doss and coworkers in Thorsby, AL. Ten more originated from south Florida, being either constant water table lysimeter or hydrologic water balance work. Sixteen were from North Carolina, seven from Raleigh and nine from Waynesville, all of which date 1963 or before. These four categories constitute 55% of the reported experiments.

Deficiencies in experimental methods were discussed in some reports. Probably the most common defect was lack of fetch for the experimental plots. Certain of the soil profile sampling methods made simplifying assumptions about runoff or drainage, but it is difficult now to judge the adequacy of these assumptions. Several of the lysimeter installations may have had non-representative surface areas for the row crop studies.

For these reasons, plus the general lack of supplementary environmental data to contribute to a mechanistic quantification of ET-climate relationships, it is concluded that insufficient high-quality ET information exists from within the region to verify either PET simulation methods or literature crop water use coefficient curves. It is further concluded that insufficient geographical or soil-variable replication exists to describe crop water use coefficient curves over the region. Finally, no single crop was represented in all states of the region. A benchmark-quality installation for precise ET measurements could allow verification or calibration of PET simulation methods. Then ET data from literature or new field experiments could be used to improve confidence in crop water use coefficient curves.

References

1. Allen, L. H., Jr., J. S. Rogers, and E. H. Stewart. 1978. Evapotranspiration as a benchmark for turfgrass irrigation. Proc. 26th Ann. Florida Turfgrass Conf. 26:85-97.

2. Allen, L. H., Jr., W. G. Knisel, Jr., and P. Yates. 1982. Evapotranspiration, rainfall, and water yield in south Florida research

watersheds. Proc. Soil & Crop Sci. Soc. Florida 41:127-139.

3. Allen, L. H., Jr., J. F. Bartholic, R. G. Bill, Jr., A. F. Cook, H. E. Hannah, K. F. Heimburg, W. H. Henry, K. Hokkanen, F. G. Johnson, and J. W. Jones. 1980. Evapotranspiration measurements. Chapter 5.6 in Florida Water Resources - NAS10-9348, Institute for Food and Agricultural Sciences, Univ. of Florida, in cooperation with NASA and the South Florida Water Management District. Gainesville, FL, 32611.

4. Allen, W. H., and J. R. Lambert. 1971a. Application of the principle of calculated risk to scheduling of supplemental irrigation: I. Concepts. Agr. Meteorol. 8:193-201.

5. Allen, W. H., and J. R. Lambert. 1971b. Application of the principle of calculated risk to scheduling of supplemental irrigation: II. Use on flue-cured tobacco. Agr. Meteorol. 8:325-340.

6. Allison, F. E., E. M. Roller, and W. A. Raney. 1958. Relationship between evapotranspiration and yields of crops grown in lysimeters receiving natural rainfall. Agron. J. 50:506-511.

7. Allred, E. R., and R. Chen. 1953. Evaluating irrigation needs in humid areas. AGRICULTURAL ENGINEERING 34(9):611-615.

8. Banks, P. A., T. N. Tripp, J. W. Wells, and J. E. Hammel. 1985. Effects of tillage on Sicklepod (*Cassia obtusifolia*) interference with soybeans (*Glycine max*) and soil water use. Weed Science (In Press).

9. Bartholic, J. F., L. N. Namken, and C. L. Wiegand. 1970. Combination equations used to calculate evaporation and potential evaporation. USDA-ARS Bull. 41-170. 14 pp.

10. Bennett, O. L., B. D. Doss, D. A. Ashley, V. J. Kilmer, and E. C. Richardson. 1964. Effects of soil moisture regime on yield, nutrient content, and evaporation for three annual forage species. Agron. J. 56(2):195-198.

11. Blaney, H. F., and W. D. Criddle. 1952. Determining water requirements in irrigated areas from climatological and irrigation data. USDA-SCS-TP-96. 48 pp.

12. Blaney, H. F., and W. D. Criddle. 1962. Determining consumptive use and irrigation water requirements. USDA-ARS Tech. Bull. No. 1275. 59 pp.

13. Boggess, W. G., J. W. Jones, D. P. Swaney, and G. D. Lynne. 1981. Evaluating irrigation strategies in soybeans: a simulation approach. Proc. ASAE Irrig. Sched. Conf. ASAE Publication No. 23-81:45-53, ASAE, St. Joseph, MI 49085.

14. Boggess, W. G., G. D. Lynne, J. W. Jones, and D. P. Swaney. 1983. Risk-return assessment of irrigation decisions in humid regions. Southern J. of Agric. Economics. 15(1):135-143.

15. Boote, K. J., J. W. Jones, G. H. Smerage, C. S. Barfield, and R. D. Berger. 1980. Photosynthesis of peanut canopies as affected by leafspot and artificial defoliation. Agron. J. 72(2):247-252.

16. Brown, L. C., and J. C. Hayes. 1984. Comparison of irrigation strategies in the Mid-South. ASAE Paper No. 84-2606, ASAE, St. Joseph, MI 49085.

17. Camp, C. R., and R. B. Campbell. 1986. Scheduling irrigation for corn in the Southeast. ARS Series. Agric. Res. Service, U.S. Dept. Agric., Washington, DC (In review).

18. Camp, C. R., G. D. Christenbury, and C. W. Doty. 1984. Tillage effects on crop yield in Coastal Plain soils. TRANSACTIONS of the ASAE 27(6):1729-1733.

19. Carreker, J. R. 1963. The relation of solar radiation to evapotranspiration from cotton. J. Geophys. Res. 68(16):4731-4741.

20. Cassel, D. K., and E. C. Edwards. 1985. Effects of subsoiling and irrigation on corn production. Soil Sci. Soc. Amer. J. 49(4):996-1001.

21. Cassel, D. K., C. K. Martin, and J. R. Lambert. 1985. Corn irrigation scheduling in humid regions on sandy soils with tillage pans. Agron. J. 77(6):851-855.

22. Choudhury, B. J., and C. A. Federer. 1983. Simulating spatial and temporal variation of corn canopy temperature during an irrigation cycle. NASA, Goddard Space Flight Center, Greenbelt, MD, Tech. Memo. 84991.

23. Christiansen, J. E. 1968. Pan evaporation and evapotranspiration from climatic data. J. Hydrol. Div., ASCE, 94(HY2):243-265.

24. Clark, G. A., D. L. Reddell, R. F. Adams, and J. C. McBurnie. 1984. Evaluation of mini-lysimeters for deficit irrigation studies. ASAE Paper No. 84-2621. ASAE, St. Joseph, MI 49085.

25. Crandall, D. A., and R. J. Luxmoore. 1982. Simulated water budgets for an irrigated sycamore phytomass farm. Forest Sci. 28(1):17-30.

26. Decker, W. L. 1966. Potential evapotranspiration in humid and arid climates. p. 23-46. In: Evapotranspiration and its role in water resources management. Proc. Evapotranspiration Conf. Dec. 5-6, 1966. ASAE, St. Joseph, MI 49085.

27. Doorenbos, J., and W. D. Pruitt. 1977. Guidelines for predicting crop water requirements. Food and Agriculture Organization of the United Nations. Irr. and Drain. Paper No. 24. 144 pp.

28. Doss, B. D., D. A. Ashley, O. L. Bennett, R. M. Patterson, and L. E. Ensminger. 1964a. Yield, nitrogen content, and water use of Sart sorghum. Agron. J. 56(3):589-592.

29. Doss, B. D., O. L. Bennett, and D. A. Ashley. 1962a. Evapotranspiration by irrigated corn. Agron. J. 54:497-498.

30. Doss, B. D., O. L. Bennett, and D. A. Ashley. 1964b. Moisture use by forage species as related to pan evaporation and net radiation. Soil Sci. 98(5):322-327.

31. Doss, B. D., O. L. Bennett, and D. A. Ashley. 1965. Moisture use by various plant species and its relation to pan evaporation and net radiation. USDA-ARS 41-112.

32. Doss, B. D., O. L. Bennett, D. A. Ashley, and H. A. Weaver. 1962b. Soil moisture regime effect on yield and evapotranspiration from warm season perennial forage species. Agron. J. 54(3):239-242.

33. Doss, B. D., and D. L. Thurlow. 1974. Irrigation, row width, and plant population in relation to growth characteristics of two soybean varieties. Agron. J. 66(5):620-623.

34. Doty, C. W. 1980. Crop water supplied by controlled and reversible drainage. TRANSACTIONS of the ASAE 23(5):1122-1126, 1130.

35. Doty, C. W., and D. C. Reicosky. 1978. Chiseling to minimize the effects of drought. TRANSACTIONS of the ASAE 21(3):495-499.

36. Dugas, W. A., D. R. Upchurch, and J. T. Ritche. 1985. A weighing lysimeter for evapotranspiration and root measurement. Agron. J. 77(5):821-825.

37. England, C. B. 1963. Water use by several crops in a weighing lysimeter. Agron. J. 55(3):239-242.

38. England, C. B., and E. H. Lesesne. 1962. Evapotranspiration research in western North Carolina. AGRICULTURAL ENGINEERING 43(9):526-528.

39. Farnsworth, R. K., E. S. Thompson, and E. L. Peck. 1982. Evaporation atlas for the contiguous 48 United States. NOAA Tech. Report No. 33. 26 pp.

40. Geddes, K. D., H. D. Scott, and L. R. Oliver. 1979. Growth and water use by common cocklebur (*Xanthium pensylvanicum*) and soybeans (*Glycine max*) under field conditions. Weed Sci. 27(2):206-212.

41. Gilbert, M. J., and C. H. M. van Bavel. 1954. A simple field installation for measuring maximum evapotranspiration. Trans. Amer. Geophys. Union 35(6):937-942.

42. Gregory, J. M., and R. W. Schottman. 1982. Irrigation scheduling procedure for subhumid areas. TRANSACTIONS of the ASAE 25(5):1290-1294.

43. Grissom, P., W. A. Raney, and P. Hogg. 1955. Crop response to irrigation in the Yazoo-Mississippi Delta. Mississippi State College Agric. Exp. Stn. Bull. 531.

44. Grubb, H. F., and A. T. Rutledge. 1979. Long-term water supply potential. Green Swamp Area, Florida. U.S. Geological Survey. Water Resources Investigations No. 78-99, Tallahassee, FL. 76 pp.

45. Hammond, L. C., R. B. Campbell, and E. D. Threadgill. 1981. Irrigation management strategies for humid regions. Proc. ASAE Irr. Sched. Conf. for Water & Energy Cons. in the 80's. ASAE Publication No. 23-81:36-44. ASAE, St. Joseph, MI 49085.

46. Hamon, W. R. 1961. Estimating potential evapotranspiration. J. Hydrol. Div., ASCE. 87(HY3):107-120.

47. Hatfield, J. L. 1983. Evapotranspiration obtained from remote sensing methods. p. 395-416. In: Hillel, D. (ed.). Advances in Irrigation. Vol. 2. Academic Press, New York.

48. Hatfield, J. L., R. J. Reginato, and S. B. Idso. 1984. Evaluation of canopy temperature-evapotranspiration models over various crops. Agric. and Forest Meteorol. 32:41-53.

49. Hayes, J. C., L. H. Chen, and R. W. McClendon. 1983. An irrigation model adapted for the Mid-South. ASAE Paper No. SER 83-005, ASAE, St. Joseph, MI 49085.

50. Heatherly, L. G., B. L. McMichael, and L. H. Ginn. 1980. A weighing lysimeter for use in isolated field areas. Agron. J. 72(5):845-847.

51. Heimburg, K. F., L. H. Allen, Jr., and W. C. Huber. 1982. Evapotranspiration estimates based on surface temperature and net radiation: development of remote sensing methods. Publ. No. 66, Florida Water Resources Research Center, Univ. of Florida, Gainesville, FL 32611.

52. Hook, J. E., E. D. Threadgill, and J. R. Lambert. 1984. Corn irrigation scheduled by tensiometer and the Lambert model in the humid Southeast. Agron. J. 76(4):695-700.

53. Howell, T. A., and E. A. Hiler. 1975. Optimization of water

use efficiency under high frequency irrigation. I. Evapotranspiration and yield relationship. TRANSACTIONS of the ASAE 18(4):873-878.

54. Jensen, M. E. 1965. Determining evapotranspiration by soil sampling. Paper, SWC Conf. of Evapotranspiration. Phoenix, AZ. 23-25 Mar., 1965.

55. Jensen, M. E. (ed.). 1974. Consumptive use of water and irrigation water requirements. Tech. Committee on Irrigation Water Requirements, Irr. and Drain. Div., ASCE, New York. 215 pp.

56. Jensen, M. E., and H. R. Haise. 1963. Estimating evapotranspiration from solar radiation. J. Irr. and Drain. Div., ASCE 89:15-41.

57. Jones, J. W., B. Zur, K. J. Boote, and L. C. Hammond. 1982. Plant resistance to water flow in field soybeans: I. Non-limiting soil moisture. Agron. J. 74(1):92-98.

58. Jones, J. W., L. H. Allen, S. F. Shih, J. S. Rogers, L. C. Hammond, A. G. Smajstrla, and J. D. Martsolf. 1984. Estimated and measured evapotranspiration for Florida climate, crops and soils. IFAS Bull. 840, Agric. Exper. Stn., Univ. of Florida, Gainesville, Dec. 1984, 65 pp.

59. Jones, J. W., and A. G. Smajstrla. 1979. Application of modeling to irrigation management of soybeans. Proc. World Soybean Res. Conf. II. F. T. Corbin, ed. pp. 571-599.

60. Jones, J. W., B. Zur, and K. J. Boote. 1983. Evaluation of a water relations model for soybean: II. Diurnal fluctuations. Agron. J. 75(2):281-286.

61. Kish, A. J. 1967. Normal daily potential evapotranspiration at the South Carolina agricultural experiment stations. Ag. Weather Res. Series No. 14. USDC-Env. Sci. Serv. Admin./South Carolina Ag. Exp. Stn., Clemson Univ., Clemson, SC.

62. Kish, A. J. 1977. 1976 climatological data of Clemson University and SC Agricultural Experiment Stations. Agric. Weather Res. Series No. 49, USDC-NOAA-NWS.

63. Knetsch, J. L., and J. Smallshaw. 1958. The occurrence of drought in the Tennessee Valley. Tenn. Valley Authority Rept. T. 58-2AE.

64. Knisel, W. G., Jr., P. Yates, J. M. Sheridan, T. K. Woody, III, L. H. Allen, Jr., and L. E. Asmussen. 1985. Hydrology and hydrogeology of Taylor Creek Watershed, Okeechobee County, Florida. USDA Tech. Bull. (In Press).

65. Kohler, M. A., T. J. Nordenson, and W. E. Fox. 1955. Evaporation from pans and lakes. U.S. Dept. of Commerce. Res. Paper No. 38. 21 pp.

66. Kohler, M. A., T. J. Nordenson, and D. R. Baker. 1959. Evaporation maps for the United States. U.S. Dept. of Commerce. Tech. Paper No. 37. 13 pp.

67. Koo, R. C. J., and J. W. Sites. 1955. Results of research and response of citrus to supplemental irrigation. Proc. Soil Sci. Soc. Florida 15:180-190.

68. Lambert, J. R. 1980. Irrigation management - humid areas. Proc. ASAE Second Nat'l Irr. Symp. ASAE Publication No. 6-81:175-184, ASAE, St. Joseph, MI 49085.

69. Lambert, J. R., C. W. Doty, and V. L. Quisenberry. 1981. Irrigation scheduling in humid areas. Proc. ASAE Irrig. Sched. Conf. ASAE Publication No. 23-81:132-143, ASAE, St. Joseph, MI 49085.

70. Lambert, J. R., and D. C. Reicosky. 1984. Dynamics of water on *Zea mays* L.: Sensitivity analysis of TROIKA. TRANSACTIONS of the ASAE 27(1):117-124.

71. Land, W. B., and J. R. Carreker. 1953. Results of evapotranspiration and root distribution studies. AGRICULTURAL ENGINEERING 34(5):319-322.

72. Makkink, G. F. 1957. Testing the Penman formula by means of lysimeters. J. Inst. Water Engin. 11:277-288.

73. Martin, C. E., B. G. Worm, and T. V. Wilson. 1979. Comparison of methods of estimating soil moisture regime. ASAE Paper No. 79-2512, ASAE, St. Joseph, MI 49085.

74. Mather, J. R. 1959. Determination of evapotranspiration by empirical methods. TRANSACTIONS of the ASAE 2(1):35-38, 43.

75. McCloud, D. E. 1955. Water requirements of field crops in Florida as influenced by climate. Soil Sci. Soc. Florida Proc. 15:165-172.

76. McGuinness, J. L., and E. F. Bordne. 1972. A comparison of lysimeter-derived potential evapotranspiration with computed values. USDA Tech. Bull. 1452. 71 pp.

77. McWhorter, J. C., and R. R. Bruce. 1963. The relation of solar radiation to measured evapotranspiration. Presented at 1963 Mtg. Assoc. of Southern Agric. Workers and SE Section of ASAE. Memphis, TN. February 4-6, 1963.

78. Mierau, R. 1974. Supplemental water use in the Everglades Agricultural Area. Tech. Publication No. 74-4, South Florida Water Management District, West Palm Beach, FL.

79. Mustonen, S. E., and J. L. McGuinness. 1968. Estimating evapotranspiration in a humid region. USDA-ARS, Tech. Bull. No. 1389.

80. Pallas, J. E., Jr., J. R. Stansell, and T. J. Koske. 1979. Effects of drought on Florunner peanuts. Agron. J. 72(5):853-858.

81. Papadakis, J. 1965. Potential evapotranspiration. Buenos Aires, 54 pp. Credited through McGuinness and Bordne, 1972.

82. Parmele, L. H., and J. L. McGuinness. 1974. Comparison of measured and estimated daily potential evapotranspiration in a humid region. J. Hydrol. 22:239-251.

83. Peacock, C. H., and A. E. Dudeck. 1984. Physiological response of St. Augustinegrass to irrigation scheduling. Agron. J. 76(2):275-279.

84. Penman, H. L. 1948. Natural evaporation from open water, bare soil, and grass. Proc. of the Royal Society, Series A. 193:120-145.

85. Penman, H. L. 1956. Estimating evapotranspiration. Trans. Amer. Geophy. Union. 37(1):43-46.

86. Phene, C. J., and O. W. Beale. 1976. High-frequency irrigation for water nutrient management in humid regions. Soil Sci. Soc. Amer. J. 40(1):430-436.

87. Phung, T., and J. F. Bartholic. 1976. Water balance in a peach orchard. In: Disposition of water from fruit crops and approaches to increase water use efficiency. Water Resources Research Center, Publication No. 33, OWRT Project No. B-014-FLA.

88. Powell, N. L., B. B. Ross, F. S. Wright, G. D. Jones, and V. O. Shanholtz. 1981. Evaluation of an irrigation scheduling system for Virginia. Proc. ASAE Irrig. Sched. Conf. ASAE Publication No. 23-81:73, ASAE, St. Joseph, MI 49085.

89. Priestly, C. H. B., and R. J. Taylor. 1972. On the assessment of surface heat flux and evaporation using large-scale parameters. Monthly Weather Review. 100(2):81-92.

90. Raney, W. A. 1955. Accuracy and reliability of soil moisture estimates. ARS, Mississippi Agric. Exp. Stn. Special Report No. 72.

91. Raney, W. A. 1959. Evaluation of evapotranspiration in field plots. TRANSACTIONS of the ASAE 2(1):41.

92. Reicosky, D. C. 1981. A research tool for evapotranspiration measurements for model validation and irrigation scheduling. Proc. ASAE Irrig. Sched. Conf. ASAE Publication No. 23-81:74-80, ASAE, St. Joseph, MI 49085.

93. Reicosky, D. C., R. B. Campbell, and C. W. Doty. 1975. Diurnal fluctuation of leaf-water potential of corn as influenced by soil matric potential and microclimate. Agron. J. 67(3):380-385.

94. Reicosky, D. C., and D. E. Deaton. 1979. Soybean water extraction, leaf water potential, and evapotranspiration during drought. Agron. J. 71(1):45-50.

95. Reicosky, D. C., C. W. Doty, and R. B. Campbell. 1977. Evapotranspiration and soil water movement beneath the root zone of irrigated and nonirrigated millet (*Panicum miliaceum*). Soil Sci. 124(2):95-101.

96. Reicosky, D. C., and D. B. Peters. 1977. A portable chamber for rapid evapotranspiration measurements on field plots. Agron. J. 69(4):729-732.

97. Rhoads, F. M., R. S. Mansell, and L. C. Hammond. 1978. Influence of water and fertilizer management on yield and water-input efficiency of corn. Agron. J. 70(2):305-307.

98. Riekerk, H. 1985. Lysimetric evaluation of pine forest evapotranspiration. p. 293-308. In: Hutchinson, B. A., and B. B. Hicks (eds), The Forest-Atmosphere Interaction. D. Reidel Publishing Co.

99. Ritchie, J. T. 1971. Dryland evaporative flux in a subhumid climate: I. Micrometeorological influences. Agron. J. 63(1):51-55.

100. Ritchie, J. T. 1973. Influence of soil water status and meteorological conditions on evaporation from a corn canopy. Agron. J. 65(6):893-897.

101. Ritchie, J. T., and E. Burnett. 1968. A precision lysimeter for row crop water use studies. Agron. J. 60(5):545-549.

102. Ritchie, J. T., and E. Burnett. 1971. Dryland evaporative flux in a subhumid climate: II. Plant influences. Agron. J. 63(1):56-62.

103. Ritchie, J. T., E. Burnett, and R. C. Henderson. 1972. Dryland evaporative flux in a subhumid climate: III. Soil water influences. Agron. J. 64(2):168-173.

104. Ritchie, J. T., and W. R. Jordan. 1972. Dryland evaporative flux in a subhumid climate: IV. Relation to plant water status. Agron. J. 64(2):173-176.

105. Robins, J. S. 1965. Evapotranspiration, Chapter 20, p. 286-298. In: C. A. Black, D. D. Evans, J. L. White, L. E. Ensminger, and F. E. Clark (eds). Methods of Soil Analysis, Part I: Physical and Mineralogical Properties, including Statistics of Measurement and Sampling. Monograph #9, American Society of Agronomy, Madison, WI.

106. Rochester, E. W., and C. D. Busch. 1972. An irrigation scheduling model which incorporates rainfall predictions. Water

Resources Bull. 8(3):608-613.
107. Rogers, J. S., and J. F. Bartholic. 1975. Estimated evapotranspiration and irrigation requirements for citrus. Soil and Crop Sci. Florida Proc. 35:111-117.
108. Rogers, J. S., L. H. Allen, Jr., and D. V. Calvert. 1983. Evapotranspiration from a humid-region developing citrus grove with grass cover. TRANSACTIONS of the ASAE 26(6):1778-1783, 1792.
109. Rosenberg, N. J., B. L. Blad, and S. B. Verma. 1983. Microclimate, the biological environment. John Wiley & Sons, New York.
110. Sanford, J. O., and J. E. Hairston. 1984. Effects of N fertilization on yield, growth, and extraction of water by wheat following soybeans and grain sorghum. Agron. J. 76(4):623-627.
111. Saxena, G. K., L. C. Hammond, and W. H. Lundy. 1971. Effect of an asphalt barrier on soil water and on yields and water use by tomato and cabbage. J. Amer. Soc. Hort. Sci. 96:218-222.
112. Sheridan, J. M., L. E. Asmussen, and W. G. Knisel, Jr. 1974. Pan evaporation at the Georgia Coastal Plain Experiment Station. Res. Bull. 159. Dept. of Agronomy, Coastal Plain Exp. Stn., Tifton, GA 31794. October, 1974.
113. Shih, S. F. 1983. Evapotranspiration and water use efficiency of sweet corn. ASAE Paper No. 83-2526, ASAE, St. Joseph, MI 49085.
114. Shih, S. F. 1984. Evapotranspiration and water use efficiency, and water table studies of sweet sorghum. ASAE Paper No. 84-2014, ASAE, St. Joseph, MI 49085.
115. Shih, S. F., L. H. Allen, Jr., L. C. Hammond, J. W. Jones, J. S. Rogers, and A. G. Smajstrla. 1981. Comparison of methods of evapotranspiration estimation. ASAE Paper No. 81-2015, ASAE, St. Joseph, MI 49085.
116. Shih, S. F., and G. Gascho. 1980. Water requirement for sugar cane production. TRANSACTIONS of the ASAE 23(4):934-937.
117. Shih, S. F., D. L. Myhre, J. W. Mishoe, and G. Kidder. 1977. Water management for sugarcane production in Florida Everglades. Proc. Int. Soc. of Sugar Cane Technologists. 16th Congress (Sao Paulo, Brazil) 2:955-1010.
118. Shih, S. F., and G. S. Rahi. 1984. Evapotranspiration of lettuce in relation to water table depth. TRANSACTIONS of the ASAE 27(4):1074-1080.
119. Shih, S. F., G. S. Rahi, and G. H. Snyder. 1982a. Evapotranspiration studies on taro in the Everglades. ASAE Paper No. 82-2595, ASAE, St. Joseph, MI 49085.
120. Shih, S. F., G. S. Rahi, G. H. Snyder, D. S. Harrison, and A. G. Smajstrla. 1982b. Relationship of rice grain yield, dry biomass, and leaf area index with evapotranspiration in south Florida. ASAE Paper No. 82-2597, ASAE, St. Joseph, MI 49085.
121. Shih, S. F., G. S. Rahi, G. H. Snyder, D. S. Harrison, and A. G. Smajstrla. 1983. Rice yield, biomass, and leaf area related to evapotranspiration. TRANSACTIONS of the ASAE 26(5):1458-1464.
122. Shih, S. F., and G. H. Snyder. 1984a. Evapotranspiration and water use efficiency of taro. TRANSACTIONS of the ASAE 27(6):1745-1748.
123. Shih, S. F., and G. H. Snyder. 1984b. Evapotranspiration, water use efficiency, and water table studies of pasture. ASAE Paper No. 84-2013, ASAE, St. Joseph, MI 49085.
124. Smajstrla, A. G., G. A. Clark, and S. F. Shih. 1984. Comparison of potential evapotranspiration calculation methods in a humid region. ASAE Paper No. 84-2010, ASAE, St. Joseph, MI 49085.
125. Stansell, J. R., and D. A. Smittle. 1980. Effects of irrigation regimes on yield and water use of snap beans (*Phaseolus vulgaris* L.) J. Amer. Soc. Hort. Sci. 105(6):869-873.
126. Stansell, J. R., J. L. Shepherd, J. E. Pallas, R. R. Bruce, N. A. Minton, D. K. Bell, and L. W. Morgan. 1976. Peanut responses to soil water variables in the Southeast. Peanut Sci. 3(1):44-48.
127. Stephens, J. C., and E. H. Stewart. 1963. A comparison of procedures for computing evaporation and evapotranspiration. Publ. No. 62 International Union of Geodesy and Geophysics, Berkeley, CA. pp. 123-133.
128. Stewart, E. H., J. E. Browning, and E. O. Burt. 1969. Evapotranspiration as affected by plant density and water-table depth. TRANSACTIONS of the ASAE 12(5):646-647.
129. Stewart, E. H., and W. C. Mills. 1967. Effect of depth to water table and plant density on evapotranspiration rate in southern Florida. TRANSACTIONS of the ASAE 10(6):746-747.
130. Stroosnijder, L., R. J. Lascano, R. W. Newton, and C. H. M. van Bavel. 1984. Estimating net rainfall, evaporation and water storage of a bare soil from sequential L-band emissivities. Proc. of the IGARSS 84 Symposium, Strasbourg, Austria. August, 1984. pp. 197-202.
131. Swaney, D. P., J. W. Mishoe, J. W. Jones, and W. G. Boggess. 1982. Using crop models for management II. Impact of weather characteristics on decisions. ASAE Paper No. 82-4568, ASAE, St. Joseph, MI 49085.
132. Thornthwaite, C. W. 1948. An approach toward a rational classification of climate. Geograph. Rev. 38(1):55-94.
133. Thornton, J. F. 1961. Moisture use by cotton in the Piedmont of Georgia. TRANSACTIONS of the ASAE 4(1):37-40, 44.
134. Turc, L. 1961. Evaluation des besoins en eau d'irrigation, evapotranspiration potentielle. Ann. Agron. 12(1):13-49.
135. USDA-SCS. 1967. Irrigation water requirements. Technical Release No. 21, USDA Soil Conservation Service, Engineering Division. 88 pp. Revised 1970.
136. USDC-NESDIS-NCDC. 1978. Maps of reporting stations. U.S. Dept. of Commerce, Nat'l Oceanic and Atmospheric Admin., Nat'l Climatic Data Center.
137. U.S. Geological Survey Open File Report 79-1289. Cited through Jones et al., 1984.
138. Van Bavel, C. H. M. 1953. A drought criterion and its application in evaluating drought incidence and hazard. Agron. J. 45(4):167-172.
139. Van Bavel, C. H. M. 1956. A regional approach to the analysis of drought incidence. USDA-ARS and North Carolina Agric. Exp. Stn. J. Paper No. 737. pp. 653-660.
140. Van Bavel, C. H. M. 1959a. Water deficits and irrigation requirements in the southern United States. J. Geophysical Res. 64(10):1597-1604.
141. Van Bavel, C. H. M. 1959b. Practical use of knowledge about evapotranspiration. TRANSACTIONS of the ASAE 2(1):39-40.
142. Van Bavel, C. H. M. 1959c. Drought and water surplus in agricultural soils of the lower Mississippi valley area. USDA/ARS Tech. Bull. No. 1209.
143. Van Bavel, C. H. M. 1961. Lysimetric measurements of evapotranspiration rates in the eastern United States. Soil Sci. Soc. Amer. Proc. 25(2):138-141.
144. Van Bavel, C. H. M. 1966. Potential evaporation: The combination concept and its experimental verification. Water Resour. Res. 2(3):455-468.
145. Van Bavel, C. H. M., and J. R. Carreker. 1957. Agricultural drought in Georgia. Georgia Ag. Exp. Stn., Univ. of Georgia Coll. of Agric. Tech. Bull. N.S. 15.
146. Van Bavel, C. H. M., L. J. Fritschen, and W. G. Reeves. 1963. Transpiration by sudangrass as an externally controlled process. Science 141(3577):269-270.
147. Van Bavel, C. H. M., L. A. Forrest, and T. C. Peele. 1957. Agricultural drought in South Carolina. South Carolina Ag. Exp. Stn. Clemson Agric. College, Bull. 447.
148. Van Bavel, C. H. M., and D. G. Harris. 1962. Evapotranspiration rates from bermudagrass and corn at Raleigh, North Carolina. Agron. J. 54(4):319-322.
149. Van Bavel, C. H. M., R. J. Lascano, and L. Stroosnijder. 1984. Test and analysis of a model of water use by sorghum. Soil Sci. 137(6):443-456.
150. Van Bavel, C. H. M., and J. H. Lillard. 1957. Agricultural drought in Virginia. Tech. Bull. 128. Virginia Ag. Exp. Stn. Dept. of Agric. Eng., Virginia Polytechnic Inst., Blacksburg, VA.
151. Van Bavel, C. H. M., and F. J. Verlinden. 1956. Agricultural drought in North Carolina. North Carolina Ag. Exp. Stn. Tech. Bull. No. 122.
152. Van Bavel, C. H. M., and T. V. Wilson. 1952. Evapotranspiration estimates as criteria for determining time of irrigation. AGRICULTURAL ENGINEERING 33(7):417-418.
153. Ward, H. S., C. H. M. van Bavel, J. T. Cope, L. M. Ware, and H. Bouwer. 1959. Agricultural drought in Alabama. Ag. Exp. Stn. of Alabama Polytechnic Inst. Bull. 316.
154. Weaver, H. A., and R. W. Pearson. 1956. Influence of nitrogen fertilization and plant population density on evapotranspiration by sudangrass. Soil Sci. 81:443-451.
155. Weaver, H. A., and J. C. Stephens. 1963. Relation of evaporation to potential evapotranspiration. TRANSACTIONS of the ASAE 6(1):55-56.
156. Williams, R. G. 1983. Watershed evapotranspiration prediction using the Blaney-Criddle approach. ASAE Paper No. 83-2523, ASAE, St. Joseph, MI 49085.
157. Williamson, R. E., and J. R. Carreker. 1970. Effect of water table levels on evapotranspiration and crop yield. TRANSACTIONS of the ASAE 13(2):168-170, 176.
158. Woolhiser, D. A., and D. E. Wallace. 1984. Mapping average daily pan evaporation. J. Irrig. and Drain. Div., ASCE 110(2):246-250.
159. Zur, B., J. W. Jones, and K. J. Boote. 1983. Field evaluation of a water relations model for soybean: I. Validity of some basic assumptions. Agron. J. 75(2):272-280.
160. Zur, B., J. W. Jones, K. J. Boote, and L. C. Hammond. 1982. Total resistance to water flow in field soybeans: II. Limiting soil moisture. Agron. J. 74(1):99-105.