APPLICABILITY OF REFERENCE CROP EVAPOTRANSPIRATION FROM MEASURED TEMPERATURE (HARGREAVES METHOD - 1982) TO SRI-LANKA

by

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This dissertation has not been previously presented in whole or part, to any University or Institution for a higher degree.

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TO MY FATHER

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LIST OF SYMBOLS AND ABBREVIATIONS

SYMBOLS

ea	-	saturated vapour pressure at mean air temperature
ed	-	mean actual vapour pressure
ET	-	evapotranspiration
ETcrop	-	crop evapotranspiration
Epan	-	pan evaporation
ET0	-	reference crop evapotranspiration
ET0*	-	reference crop evapotranspiration not adjusted
f	-	consumptive use factor
f(ed)	-	function of ed
f(n/N)	-	function of n/N
f(t)	-	function of temperature
f(u)	-	function of wind
k	-	consumptive use crop factor
kc	-	crop coefficient
kp	-	pan coefficient
L	-	reflection coefficient
n	-	measured bright sunshine hours
N	-	maximum possible sunshine hours
p	-	percentage of day time hours
Ra	-	extraterrestrial radiation
RH	-	relative humidity
RH mean	-	mean relative humidity
RH min	-	minimum relative humidity
Rn	-	net radiation
Rnl	-	net long wave radiation
Rns	-	net short wave radiation
Rs	-	solar radiation
t	-	temperature
Tc	-	mean temperature
TD	-	difference of maximum and minimum temperatures
U	-	wind speed
U2	-	wind speed at 2m height
w	-	temperature related weighting factor

ABBREVIATIONS

C	-	Celsius
cm	-	centimetre
dia	-	diameter
ft	-	feet
F.A.O.	-	food and agricultural organisation
hr	-	hour
Ha	-	hectare
in	-	inch
km	-	kilometre
km/day	-	kilometres per day

km/hr	-	kilometres per hour
m	-	meter
m	-	meter square
m.bars	-	millibars
mm	-	millimetre
mm/d	-	millimetres per day
m/sec	-	meters per second
M.S.L.	-	mean sea level
°'N	-	northing
T	-	tonne

ABSTRACT

Considering the problems associated with the availability and reliability of climatic data in developing countries and the possible errors in the more sophisticated methods for estimating crop water requirements, it has become necessary to develop a computational procedure which requires least and widely available data.

The method of estimating reference crop evapotranspiration (ET0) from measured temperature introduced by professor Hargreaves of Utah State University in 1982 has given satisfactory results in many regions of the world. The study of its applicability to Sri- Lanka could do much to improve irrigation and agricultural sectors.

Three stations from different climatic regions of Sri-Lanka were selected with the intention of studying the applicability of this new method. ET0 estimates from Modified Penman, Hargreaves and Pan evaporation methods were computed for seven years and the average values were compared. The results indicated that the Hargreaves method provides satisfactory results for Yala seasons in dry zone. The application of Hargreaves method can be extended even to Maha seasons in dry coastal regions.

The ET0 estimates from Modified Penman method have given over predictions specially for high wind velocities.

Two average years were selected for station Mahaillluppallama and Batticaloa. ET0 estimates from Modified Penman were computed for varying wind speeds. The results have shown that a local calibration is required for the aerodynamic term of Modified Penman equation.

A relationship has been developed between maximum and minimum temperatures, relative humidity, wind speed and the deviation of ET0 values of Hargreaves method from pan evaporation method. This indicated that for given temperatures and relative humidity, Hargreaves method provides better results only for a particular range of wind speed.

Estimated crop evapotranspiration (ET crop) for soya beans from Hargreaves and Pan evaporation methods were compared with lysimeter measurements for Agricultural Research Station Mahailluppallama. The total estimated ET crop from Hargreaves method has only varied 5.6 % from the measured lysimeter values.

INTRODUCTION

With limited water and fertile land and with the increase in population, the need for more and better food production has become an important matter for most regions of the world.

The fundamental questions to be asked from a person who is trying to solve this problem are regarding the avenues available to improve food production. These avenues could be summarised as follows.

1. Development of new fertile land that can be made productive with the available water resources.

2. Suitable practices to use fertilisers and pesticides.

3. Use of improved varieties of plants and crops.

4. Proper management of irrigation water, both in conveyance and field levels.

5. Conversion from surface to drip or sprinkle systems whenever conditions of soils, topography and economics indicate clear advantages.

6. Looking for improved estimates of crop water requirements.

This study deals with the last of the six avenues.

For effective planning, scheduling and operation of irrigation systems and for feasibility studies of proposed irrigation projects, the accurate quantitative prediction of crop water plays a major role.

Several methods are available for the estimation of potential evapotranspiration of a reference crop or reference crop evapotranspiration (ET0). Evapotranspiration for other crops can be estimated using ET0 and established crop coefficients which are presented accounting crop characteristics, time of planting or sowing, the general climatic conditions and stages of crop development.

Four widely used methods recommended by Food and Agricultural Organisation for the computation of reference crop evapotranspiration are Blaney-Cridole, Modified Penman, Radiation and Pan evaporation. These methods require measured and estimated data for a reference area. But in many developing countries data may be incomplete and estimates or data from other locations are used for computations. For example, climatic data for estimating ET0 may be taken from

airports, arid hilly locations or from other irrigated areas dissimilar to the areas for which ETO computations are needed. Therefore it has become important to develop computational procedures which require minimum and widely available data. These procedures should provide reliable results.

Mcvicker(1982) calibrated 12 methods for estimating Reference crop evapotranspiration (ETO) which are based on air temperature and incoming solar radiation (Rs). He compared their performances for two locations Davis, California and Logan, Utah. The best six methods ranked in order of the smaller root mean square error are Hargreaves, Jensen-Haise, Stephens and Stewart, Makkink, Turc and Grassi. All these performed better than Penman equation.

Shih (1984) evaluated the data requirements for evapotranspiration estimates. The estimates from nine climatic variables were compared with calculated values using two variables of air temperature and solar radiation. The two variables provided satisfactory estimates for Southern Florida.

Several methods for estimating reference crop evapotranspiration (ETO) were compared by Salih and Sendil (1984) using ETO data from Alfalfa for two sites in Al-Hassa region of Saudi Arabia. Field plot technique was used at one site and a lysimeter at the other. Statistically based evaluation was done. The results ranked are Jensen-Haise and the class-A Pan methods in first place, Hargreaves method next and then Penman & Modified Penman.

The study by Mcvicker (1982), the comparisons made by Shih (1984) and those by Salih and Sendi (1984) indicated that two climatic variables of mean air temperature and global solar radiation can be used to provide satisfactory estimates of potential evapotranspiration (ETO) at most locations. However some judgement or local calibration may be desirable for advective conditions of wind which provides significant cooling or heating of the reference area. The study of the applicability of these new methods to Sri-Lanka could be much useful and could do much to improve irrigation planning, designs and scheduling.

OBJECTIVE

Considering the problems associated with the availability and reliability of climatic data and the possible errors in the more sophisticated methods for estimating crop water requirements, it is very much useful to study a method of estimating reference crop evapotranspiration with minimum and widely available data and which provides reliable results.

The general objectives of this study are as follows

(a) Determine and compare the reference crop evapotranspiration (ET0) from Hargreaves method (1982) with other methods for Agricultural Research Station Mahailluppallama.

(b) Repeating the above, for weather station Batticaloa and Research Station Peradeniya.

(c) Study of the applicability of Hargreaves method (1982) for specific areas in Sri-Lanka.