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Determination of Water Requirements of Principal Crops Grown In Krishna District of Andhra Pradesh State, India

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ABSTRACT: Water is a precious national resource. The development of surface as well as ground water for increasing the agricultural production to meet the growing requirement of Indian population is a must. The object of work is aimed to supply the controlled water to vast cultivated area to improve the existing crop pattern and also ensure irrigation to the fields against vagaries of rainfall. Agriculture is the main stray for 70% of the households. Rice is a staple food of the people and Paddy is therefore the principal crop of the district followed by black gram, Sugarcane, maize, green gram, horse gram, red gram jowar etc., are important. The water requirement of crop varies widely from crop to crop and also during the entire crop period of individual crop. Thus estimation of crop water requirements considering the crop pattern has been an area which has attracted attraction of water resources planners and engineers. The main parameter which is required to be determined for estimating the crop water requirements is Crop Evapotranspiration (ETo) which when multiplied with the crop factor gives the value of water required for the crop. The actual evapotranspiration can be measured in the field with the help of lysimeter but it is not always possible. Therefore some analytical methods are required for evaluating ETo values. In this paper Reference crop evapotranspiration (ETo) was determined using the FAO Penman Monteith method, and by Blaney criddle method. The values on the higher side are taken for scheduling of crops.

KEYWORDS: Agriculture, Water requirement, Crop Evapotranspiration, (ETo)

I. INTRODUCTION

Krishna district is one of the north-eastern coastal districts of Andhra Pradesh and it lies between 15^0 -43^1 and 17^0-10^1 of northern latitude and 80^0 and 81^0-33^1 of eastern longitude. The district receives annual rainfall of 1689.8 mm of which southwest monsoon accounts for 64.5% of the total while north east monsoon contributes 27.8% of the total rainfall during 2010-11. The rest is shared by summer showers and winter rains. The total geographical area is 8,72,700 hectares of this 35.37% is arable area while 9% is forest area. The rest is distributed among “Barren and uncultivable land” about 5% and “Land put to non-agricultural uses about 18%. Out of the cultivable area, the net area sown form 56% while cultivable waste and fallow lands constitute about 6% during 2010-2011. In the present study the crop water need for the principle crops is evaluated for irrigation planning using climatic indices.

The improvement of irrigation systems offers increased yields and crop intensity which in turn, leads to the development of all sectors of economy. Irrigation systems can be improvised by taking into consideration various climatic factors and local conditions. The rainfall of our country is dependent on the monsoons. Rainfall controls our agriculture. But the agriculture of our country is said to be, "the gambling of the monsoon" as the monsoon rainfalls are uncertain, irregular and uneven or unequal. Complete knowledge of moisture status of the particular region, its normal and fluctuating climatic conditions, the frequencies and intensities of the natural disasters is essential for proper agricultural planning. In addition, it is also necessary to understand the suitability of the region for different types of crops within the framework of the climatic conditions and different types of water sources of the region i.e. minor, medium and major in order to achieve the best possible results in terms of production.

[1]. Evapotranspiration (ET) equations such as the theoretically based Penman combination are available to account for the effects of solar

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radiation, temperature, dryness and movement of the air environment on the evapotranspiration process by considering energy and aerodynamic transfer. The lack of availability of climatological data in many areas and during the historical periods necessitates the use of approaches which incorporate the effects of temperature and day length only. The FAO Blaney-Criddle method (FAO-BC) is unique from the original and in a study conducted by Richard G .Allen et al. (1986), practical procedures and necessary conditions for obtaining a reasonable estimate of consumptive use with the FAO Blaney-Criddle formula are discussed. Richard G.Allen (1948) suggested that soil moisture may have considerable effect on evapotranspiration & potential evapotranspiration was equal to actual evapotranspiration that would occur when there was an adequate supply of soil moisture at all times.

[2]. The widely- used Penman- Monteith equation to estimate crop evapotranspiration (ET) has limited utility in many areas of the world due to its requirement for full meteorological data. Legal and engineering water agencies commonly use the original Blaney- Criddle method (1962) in their efforts to manage competing water demands in mountain basins, both for its long- time familiarity and minimal data requirements. The original Blaney- Criddle equation predicts crop ET based solely on readily available mean monthly air temperature t, and percentage of daylight hours. However, in semi- arid, high- elevation environments, Blaney- Criddle underestimates crop ET. Keeping this in view Darcy G et al. (2011), evaluated three modifications of the Blaney- Criddle temperature expression against the original equation with mean t, and another temperature method, Hargreaves, using lysimeter measurements from nine irrigated grass meadow sites in the upper Gunnison River basin of Colorado (1999–2003). Two of the modified temperature expressions resulted in improved correlation of Blaney- Criddle estimated crop ET with lysimeter ET. Similar improvements were observed when estimating with Hargreaves, which incorporates an additional term, Tdiff, the difference between maximum and minimum daily temperature. It was opined that, these modifications to the original Blaney- Criddle can be applied successfully throughout Colorado mountain basins, and may be globally applicable to high- elevation areas.

[3]. The Penman-Monteith equation is the most common method for estimating reference crop evapotranspiration (ETo). However, this method needs full weather data, but few stations with complete weather data exist in Fars province of Iran. In a study, conducted by Hamid Reza Fooladmand et al. (2007) using the weather data of seven synoptic stations in Fars province in Iran and seven synoptic stations outside the province, the Hargreaves equation was calibrated based on the Penman-Monteith method for every month of the year and for a yearly time step. The results indicated that different coefficients should be used for each month of year and yearly time step instead of the original coefficient of 0.0023 in the Hargreaves equation.

[4]. CROPWAT 8.0 is a computer model for the calculation of crop water and irrigation requirements from the existing climatic and crop data and using the reference evapotranspiration (ETo). The ETo to be used in this CROPWAT is to be evaluated using Penman-Monteith formula. One such work was done Waseem Raja (2010) with Kashmir valley as the study area. [5].The idle speed control problem of a spark-ignited engine equipped with a camlessvalvetrain is considered.

II. PRINCIPAL CROPS GROWN IN KRISHNA DISTRICT

III. ESTIMATION OF REFERENCE EVAPOTRANSPIRATION

The reference crop evapotranspiration ETo (mm/day) is calculated using Blaney-Criddle formula by using climatic indices and using meteorological data Penman-MontiethETo's are calculatedfor last three years.

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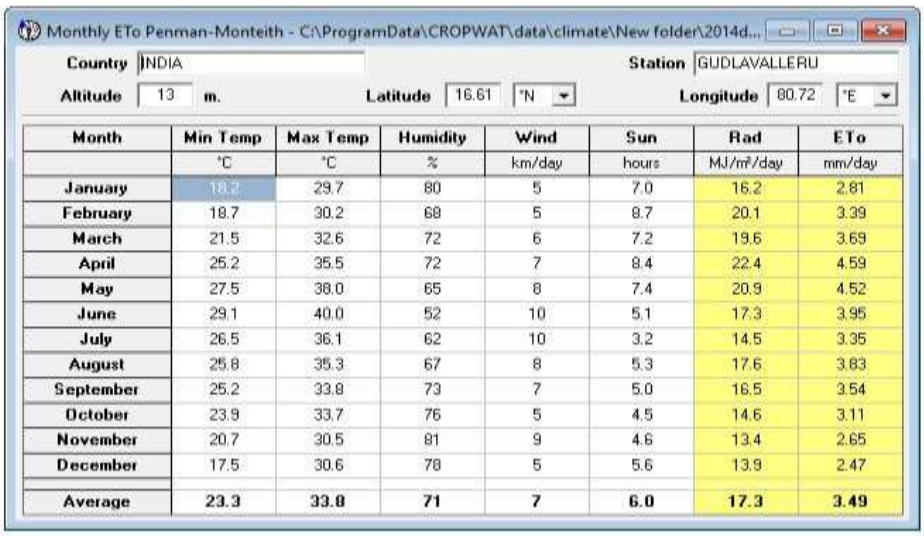
In 1948, Penman combined the energy balance with the mass transfer method and derived an equation to compute the evaporation from an open water surface from standard climatological records of sunshine, temperature, humidity and wind speed. This so called combination method was further developed by many researchers and extended to cropped surfaces by introducing resistance factors

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

Where
ETo reference evapotranspiration [mm day^{-1}],
Rn net radiation at the crop surface [MJ m^{-2} day^{-1}],
G soil heat flux density [MJ m^{-2} day^{-1}],
T mean daily air temperature at 2 m height [°C],
u_2 wind speed at 2 m height [m s^{-1}],
es saturation vapour pressure [kPa],
ea actual vapour pressure [kPa],
e_s - e_a saturation vapour pressure deficit [kPa],
Δ slope vapour pressure curve [kPa $°C^{-1}$],
γ psychrometric constant [kPa $°C^{-1}$]

Another set of Evapotranspiration values are calculated using Blaney - Criddle formula as stated below
ETo= p (0.46 Tmean + 8)
ETo =Reference crop evapotranspiration (mm/day) as an average for a period of1month
T mean = mean daily temperature (°C)
p = mean daily percentage of annual daytime hours



Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	18.2	29.7	80	5	7.0	16.2	2.81
February	18.7	30.2	68	5	8.7	20.1	3.39
March	21.5	32.6	72	6	7.2	19.6	3.69
April	25.2	35.5	72	7	8.4	22.4	4.59
May	27.5	38.0	65	8	7.4	20.9	4.52
June	29.1	40.0	52	10	5.1	17.3	3.95
July	26.5	36.1	62	10	3.2	14.5	3.35
August	25.8	35.3	67	8	5.3	17.6	3.83
September	25.2	33.8	73	7	5.0	16.5	3.54
October	23.9	33.7	76	5	4.5	14.6	3.11
November	20.7	30.5	81	9	4.6	13.4	2.65
December	17.5	30.6	78	5	5.6	13.9	2.47
Average	23.3	33.8	71	7	6.0	17.3	3.49

CALCULATION OF ETO USING CROPWAT 8.0

IV. CALCULATION OF IRRIGATION WATER REQUIREMENT USING PENMAN- MONTEITH METHOD ETO'S

The gross irrigation requirement (IRR) or crop water needs are calculated using the following equation
Gross irrigation requirement (IRR) = Net irrigation requirement/water application efficiency
IRR = Wr / 0.85 (for Paddy) (mm/month)
IRR = Wr / 0.65 (for the crops other than Paddy) (mm/month)
Where:
Net irrigation requirement at the field level (Wr) = (Consumptive use-effective rainfall land preparation needs +Percolation losses) (mm/month)
Wr = (Cu – Er) + 250 for Paddy (mm/month)
Wr = (Cu – Er) other than Paddy (mm/month)
CU = Consumptive Use = ETo x Kc (mm/day)
Kc= Crop-coefficient
ETo is Reference evapotranspiration Calculated using Penman – Monteith method (Cropwat 8.0)
Er = effective rainfall = Peff

Calculation of Irrigation Water Need: Crop Water need for various crops is calculated using ETo's calculated by using Blaney-Criddle formula. The crop water need is calculated using the following expression.

IN = ET crop + SAT + PERL + WL – Pe
ETcrop = ETo x Kc

Where, ETo = Reference Evapotranspiration

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(mm/day)
Kc = Crop Coefficient
SAT = Water needed to saturate the soil or land preparation bypuddling = 200 mm for rice and zero for other principle crops
PERC = the percolation and seepage losses
for clay soils PERC = 4 mm/day
for sandy soils PERC = 8 mm/day
an average value of 6 mm/day can be considered for mixed soils.
WL = the amount of water need to establish a water layer during transplanting or sowing and maintained throughout the growing season and it is equal to 100mm for paddy and zero for other principle crops.
Pe=Er=Peff= the monthly effective rainfall is determined using equation (mm)
Net irrigation requirement at the field level (Wr) = (Consumptive use-effective rainfall land preparation needs +Percolation losses) (mm/month)
Wr = (Cu – Er) + 250 for Paddy (mm/month)
Wr = Cu – Er) other than Paddy (mm/month)
CU = Consumptive Use = ETo x Kc (mm/day)
Kc= Crop-coefficient
ETo is Reference evapotranspiration Calculated using Penman – Monteith method (Cropwat 8.0)
Er = effective rainfall = Peff
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Irrigation water need using Penman-MonteithETo

Sl.No.	Name of the Crop	2016-17	2017-18	2018-19
		IRR/hectare(mm)	IRR/hectare(mm)	IRR/hectare(mm)
1	Rice kharif	1973.01	1091	1882
2	Rice rabi	1794.38	1696	1781
3	Black gram khariff	157	-648	-102
4	Black gram rabi	264	117	399
5	Green gram khariff	169	-636	-107
6	Green gram rabi	202	53	337
7	Sugarcane	1535	99	1318
8	Maize khariff	255	-681	-122
9	Maize rabi	520	420	508
10	Red gram	425	-751	350
11	Jowar	246	-775	27
	Total	7540.04	-15	6271

Irrigation water need using Blaney-CriddleETo

Sl.No.	Name of the Crop	2016-17	2017-18	2018-19
		IRR/hectare(mm)	IRR/hectare(mm)	IRR/hectare(mm)
1	Rice kharif	1248	855	1445
2	Rice rabi	1390	1316	1455
3	Black gram khariff	196	-290	51
4	Black gram rabi	276	200	356
5	Green gram khariff	198	-283	52
6	Green gram rabi	219	142	301
7	Sugarcane	1288	462	1318
8	Maize khariff	267	-288	57
9	Maize rabi	428	369	411
10	Red gram	488	-194	438
11	Jowar	289	-324	159
	Total	6287	1965	6043

Average gross irrigation water requirement for the principle crops 2016-17 to 2018-19

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Sl.No.	Name of the Crop	IN/hectare(mm) Blaney-Criddle	IRR/hectare (mm Penman-Monteith)
1	Rice kharif	1182.67	1648.67
2	Rice rabi	1387	1757.13
3	Black gram khariff	-14.33	-197.67
4	Black gram rabi	277.33	260
5	Green gram khariff	-11	-191.33
6	Green gram rabi	220.67	197.33
7	Sugarcane	1022.67	984
8	Maize khariff	12	-182.67
9	Maize rabi	402.67	482.67
10	Red gram	244	8
11	Jowar	41.33	-167.33
	Total	4765.01	4598.8

V. OBESERVATIONS FROM THE TESTS CONDUCTED SOLENOID FORCE

From the above mentioned tables it is evident that the gross irrigation water requirements evaluated in Blaney-Criddle method is found to be higher side. However these values are considered more accurate than the former why because the Blaney-Criddle method includes parameters like percolation losses, water requirement for layer formation in case of paddy etc, Hence these values are to be considered for further analysis in the present work and as per these calculations the average gross irrigation water requirement for all the principle crops grown in the study area is4765.01mm/hectare.

The actual force required in the application is need to move the engine valve along with spring that must be considered.

VI. CONCLUSION

From the calculations of ETo by Penman-Monteith (CROPWAT 8.0) and Blaney-Criddle formula and the subsequent calculations of irrigation water requirements using Penman-Monteith and Blaney-CriddleETo's, it is observed that the gross irrigation water requirements evaluated in Blaney-Criddle method are found to be on higher side. However, these values are considered in the present study because the Blaney-Criddle method includes parameters like percolation losses, water requirement for layer formation in case of paddy etc.

A well-managed irrigation system is one that optimizes the spatial and temporal distribution of water, so as to promote crop growth and yield, and to enhance the economic efficiency of crop production. Krishna district experiences diverse climatic conditions due to the imbalance distribution of monsoon rainfall. The Evapotranspiration (ET) Method is an excellent way to determine how much water to apply based on estimates of the amount of water lost. The crops in the area in relation to irrigation potential and crop evapotranspiration have been examined. Large potential differences can be expected between the SCS Blaney-Criddle and the Penman-Monteith methods, with underestimations some months and overestimation in other months. The total Irrigation water need (IN) for Principle crops in the district was 4765.01 mm/hectare as per Blaney Criddle method it is 4598.8mm/hectare as per Penman-Monteith method. The Water requirement is more in case of Blaney-Criddle so for irrigation scheduling the values on the higher side must be taken. About 48% of the gross cropped area is under the three major irrigation sources namely Krishna delta, Nagarjuna agar project and Muniyeru project, the rest about 34% of the gross cropped area is irrigated under the ayacut of the medium irrigation system and minor irrigation under tanks, tube wells and other sources. The rest of the cultivated area is covered under dry crops depending upon the vagaries of the monsoon. The district receives majority of the rainfall in Khariff so in Rabi the crops that require less water requirement must be practiced for proper irrigation planning.

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