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Estimation of Crop water Requirement for Kolar Taluk Sub watershed

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Abstract*- The water balanced of a place, whether it be an agricultural field, watershed, or continent, can be determined by calculating the input, output, and storage changes of water at the Earth's surface. The major input of water is from precipitation and output is evapotranspiration. The water balance is intended for use as a screening tool to further evaluates water resources allocations within the watershed and to identify water balance components that may require further analysis during the next levels of watersheds planning. The study area chosen for the present study area is Doddavalabhi sub watershed which falls in Kolar taluk of Kolar district. The study areas geographically lies between 760 8' 0" E and 760 23' 0" E longitude and 120 20' 0" N and 120 28' 0" N latitudes with an area 15.20 sq.km. For the determination of crop water requirement for Kolar major crops considered are ragi and groundnut with the crop period of 120 days and 140 days respectively. The year and monthly wise potential evapotranspiration and actual evapotranspiration is calculated by using penman method, blaney-criddle method, pan evaporation and radiation methods. The year wise potential evapotranspiration calculated by Blaney-criddle is maximum 645.66 mm during 2014, in this year monthly PET is maximum in July month ie 150.4mm. The year wise potential evapotranspiration calculated by Pan Evaporation is maximum 236.43 mm during 2014, in this year monthly PET is maximum in July month ie 56.67mm. The Year wise actual evapotranspiration is also maximum during 2014 for both ragi and groundnut. Hence Blaney criddle method is best suitable since it provides the most satisfactory results compared to other methods because this method is suggested for areas where available climatic data cover air temperature data only.

Index terms- Watershed management, Evapotranspiration and Water balance components

INTRODUCTION

Water is an important component for plant growth. It constitutes three-fourth of the body weight. The water is either supplied by rain or irrigation. An efficient utilization of irrigation is essentials to supply water at the different critical stages during plant growth to determine the economic loss. Climate, soil and water are the three basic resources which determine the nature of crops that can be grown successfully in a particular region.

Water requirement of a crop is the quantity of water needed for normal growth and yield and mays be supplied by precipitation or by rain or by both. Water needed mainly to meet the demands of evaporation (E), transpiration (T) and metabolic needs of the plants, all together known as consumptive use (CU).

CU = E + T + water needed for metabolic purposes

Evapotranspiration

Evaporation and transpiration occur simultaneously and there is no easy way of distinguishing between the two processes. Apart from the water availability in the top soil, the evaporation from a cropped soil is mainly determined by the fraction of the solar radiation reaching the soil surface. This fraction decreases over the growing period as the crop develops and the crop canopy shades more and more of the ground area. When the crop is small, water is predominately lost by soil evaporation, but once the crop is well developed and completely covers the soil, transpiration becomes the main process.

Potential and Actual Evapotranspiration

When sufficient moisture is freely available to completely meet the needs of the vegetation fully coverings an area, the resulting evapotranspiration is called Potential evapotranspiration (PET).The real evapotranspiration occurring in a specific situation in the field is called the actuals evapotranspiration (AET). It has been further established that PET depends upon the climatologically factors, whereas the AET largely affected by the characteristics of soil and vegetation.

Reference crop evapotranspiration (ETO)

The evapotranspiration rate from a reference surface, not short of water, is called the reference crop evapotranspiration or reference evapotranspiration and is denoted as ETo. The referenced surface is a hypothetical grass reference crop with specific characteristics. Doorenbos and Pruitt (1977) defined reference crop evapotranspiration as the "Evapotranspiration from an extensive surface of 8 to 15 cm (3 to 6inches) tall, green grass cover of uniform height, actively growing, completely shading the ground and not short of water" is related.

Crop evapotranspiration under standard conditions (ETc)

The crop evapotranspiration under standard conditions, denoted as ETc, is they evapotranspiration from disease-free, well-fertilized crops, grown in large fields, under optimum soil water conditions, and achieving full production under the given climatic conditions. The parameter which is estimated in the current study is evapotranspiration. Estimation of evapotranspiration is one of the major hydrological components and it is very important forr determining crop water requirement, scheduling irrigation at a regional level. Therefore, reliable and consistent estimate of evapotranspiration is of great importance for the efficient management of water resources.

STUDY AREA AND DATA PRODUCTS

The study area chosen was Doddavallabhi sub watersheds of Kolar Taluk , Kolar District. The study arear geographically lies between North latitude 12° 46' to 13° 58' and East Longitude 77° 21' to 78° 35'. The watershed area geographically covers an area of 15.20 Sq. km. The topography of the area is undulating to plain. The central and eastern parts of the district forming the valley of Palar Basinr are well cultivated. The northern part of the area forms a depression forming the valley of the Northt Pinakini River towards Gauribidanur. The general elevation varies from 249 to 911 m above mean sea level.

The soils of Kolar district occur on different landforms such as hills, ridges, pediments, plains and valleys. The types of soils distributed range from red loamy soil to red sandy soil and lateritic soil. Of the total area, about 73% is suitable for agriculture and horticulture about 3% for forestry, pasture and the remaining area is suitable for quarrying, mining and as habitat for wildlife. The area of the watershed is obtained from delineating the top sheets covering 57 K/4 and 57 G/16 of 1:50000 scale by using ARC GIS software. The area of the watershed is found to be 15.20 km2. Daily weather data of Kolar study area are collected from (KSNMDC), Kolar for 2014 & 2015 has been used.

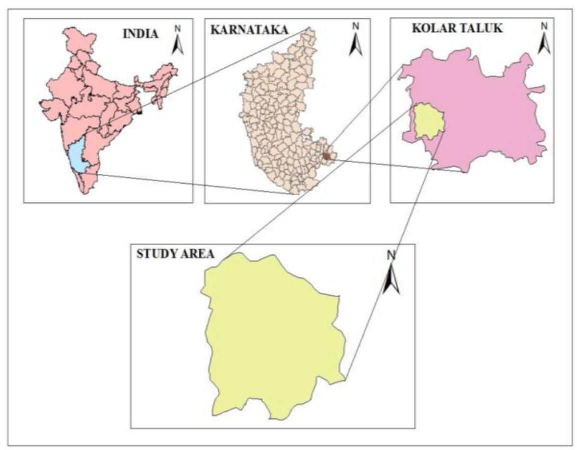


Fig No.1: Location Map of Study Area

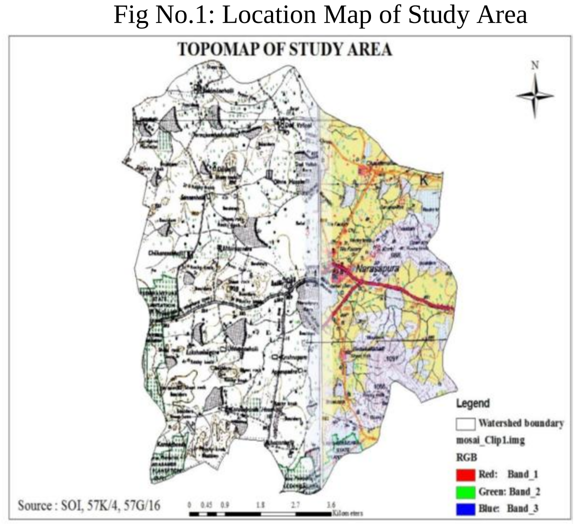


Fig No.2: Top map of Study Area

METHODOLOGY

A large number of more or less empirical methods have been developed over the last 50 years by numerous scientists and specialists worldwide to estimate evapotranspiration from different climatic variables. Relationships were often subject to rigorous local calibrations and proved to have limited global validity. Testing the accuracy of the methods under a new set of conditions is laborious, time-consuming and costly, and yet evapotranspiration data are frequently needed at short notice for project planning or irrigation scheduling design. To meet this need, guidelines were developed and published in the FAO Irrigation and Drainage Paper No. 24 'Crop water requirements'. To accommodate users with different data availability, four methods were presented to calculate the reference crop evapotranspiration (ETo):

A. BlaneyCriddle Method

This method is suggested for areas where available climatic data cover air temperature data only. The original Blaney-Criddle, (1950) involves the calculation of the consumptive use factor (f) from mean temperature (T) and percentages (p) of total annual day light hours occurring during the period being considered. An empirically determined consumptive use crop coefficient (K) is then applied to establish the consumptive water requirements (Cu).

$$Cu = K.fc = K\,(p.\frac{T}{100}) \quad \text{----------------------} \quad (1.1)$$

For a better definition of the effect of climate on crop water requirements, but still employing the Blaney-Criddle temperature and day length related f factor, a method is presented to calculate reference crop evapotranspiration (ET_0). Using measured temperature data as well as general levels of humidity, sunshine and wind, an improved prediction of the effect of climate on evapotranspiration should be obtainable. The presented crop coefficients given under 1.2 are considered to be less dependent on climate.

The relationship recommended, representing mean value over the given month, is expressed as:

$$ET_0 = cv[p(0.46T + 8)] \qquad mm/day \qquad (1.2)$$

B. Radiation Method

This method is suggested for areas where available climatic data include measured air temperature and sunshine. Cloudiness or radiation, but not measured wind and humidity. Knowledge of general levels of humidity and wind is required, and these are to be estimated using published weather descriptions, extrapolation from nearby areas or from local sources. Relationships are given between the presented radiation formula and reference crop evapotranspiration (ET_0), taking into account general levels of mean humidity and daytime wind. The relationship recommended (representing mean value over the given period) is expressed as:

$$ET_0 = cb(w.Rs) \qquad mm/day \qquad (1.3)$$

C. Penman Method

For areas where the measured data such as temperature, humidity, wind and sunshine duration or radiation are available an adaption of the Penman method is suggested. Penman, 1948 provides the most satisfactory results compared to other methods because of the two terms namely energy term and aerodynamic term. A slightly modified Penman equation is suggested to determine ET_0, involving a revised wind function term. This method uses mean daily climatic data since day and night time weather conditions considerably affect the level of evapotranspiration, an adjustment for this is included. The form of equation used in this method is:

$$ET_0 = cb\,[w.\,R_n + (1\text{-}w).\,f\,(u).\,(e_a\text{-}e_d)] \qquad (1.4)$$

D. Pan evaporation Method

Evaporation pans provide a measurement of the integrated effect of radiation, wind, temperature and humidity on evaporation from a specific open water surface. In a similar fashion the plant responds to the same climatic variables but several major factors may produce significant differences in loss of water.

Referenced crop evapotranspiration (ETo) can be obtained from:

$$ET_0 = Kp.Epan \;\ldots\ldots\ldots\ldots\; \text{mm/day} \qquad (1.5)$$

Actual evapotranspiration

To estimate the actual evapotranspiration of crops such as ragi and groundnut are considered.

Selection of crop coefficient

To account for the effect of the crop characteristics on crop water requirements, crop coefficients (kc) are used to relate ETo to crop evapotranspiration (ET crop). The kc value relates to evapotranspiration of a disease – free crop grown in large fields under optimum soil water and fertility conditions and achieving full production potential under the given growing environment. ET crop can be found by:

$$ETcrop = kcv*ETo \tag{1.6}$$

RESULTS AND DISCUSSIONS

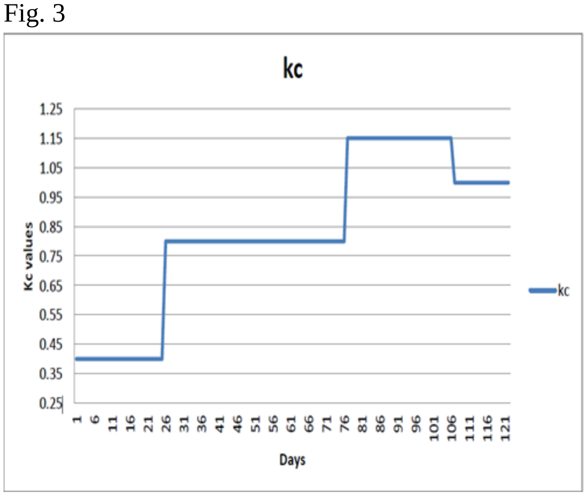
Reference crop evapotranspiration is estimated for all the four methods and it is seen that the highest estimate is by Blaney-Criddle followed by Penman and the lowest estimates is Radiation and followed by the Pan Evaporation methods.

Table 1 Year wise annual evapotranspiration (mm) of Kolar by Penman, Blaney-Criddle, Radiation and Pan Evaporation methods

Year	PET (mm)			
	Penman	Balney-Criddle	Radiation	Pan evaporation
2014	447.83	645.66	443.33	236.43
2015	420.39	642.4	410.61	192.32

Selection of crop coefficient

For estimation of crop evapotranspiration, the dominant crops such as Ragi and Groundnut are considered. Based on the phonological conditions, the crop coefficient curve is obtained and is shown in Fig. 3



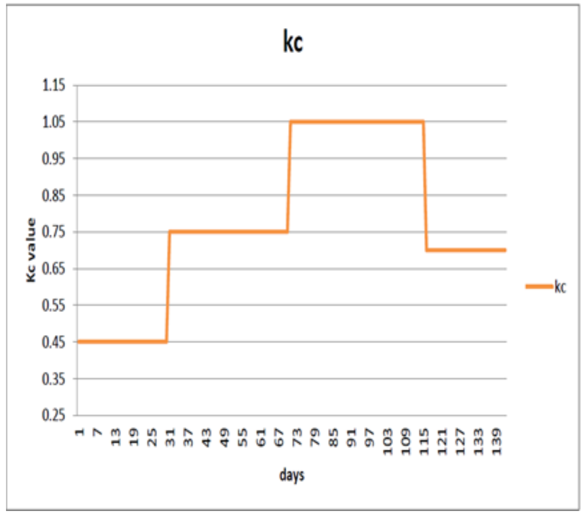
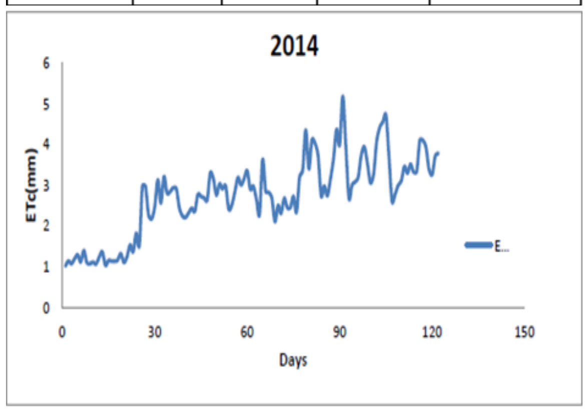
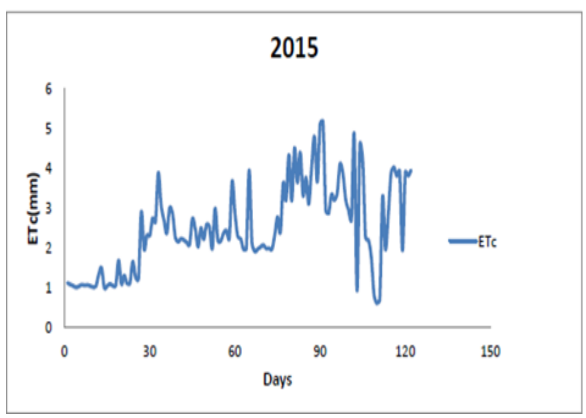


Fig.3 Crop coefficient curve for Ragi and Groundnut crops

Table 2.Year wise actual evapotranspiration (mm) of Ragi crop

year	Penman	Blaney criddle	Radiation	Pan evaporation
2014	334.01	436.96	369.15	161.32
2015	303.80	435.04	317.46	147.05





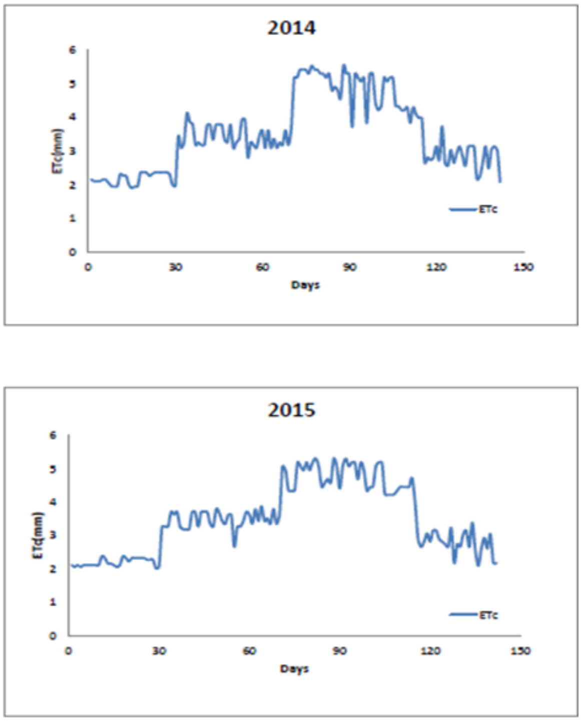


Fig.4. Daily actual evapotranspiration of Ragi crop by penman and Blaney – criddle methods

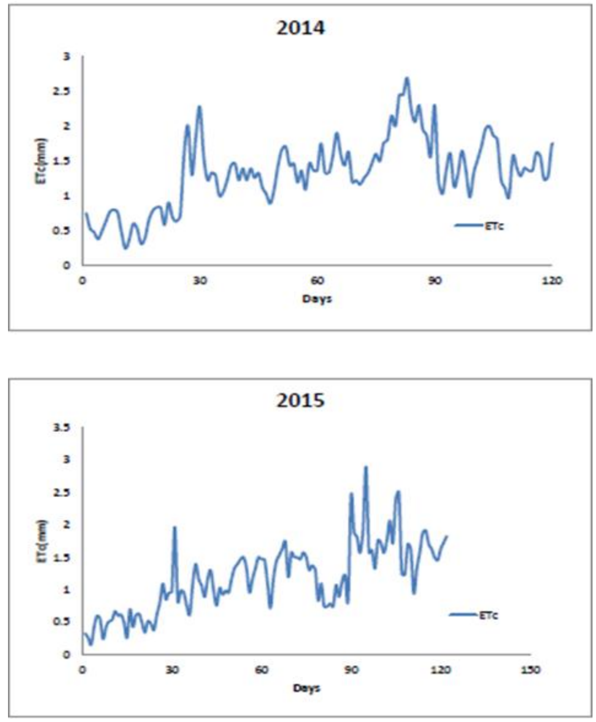


Fig. 5. Daily actual evapotranspiration of Ragi crop by Radiation and Pan evaporation methods

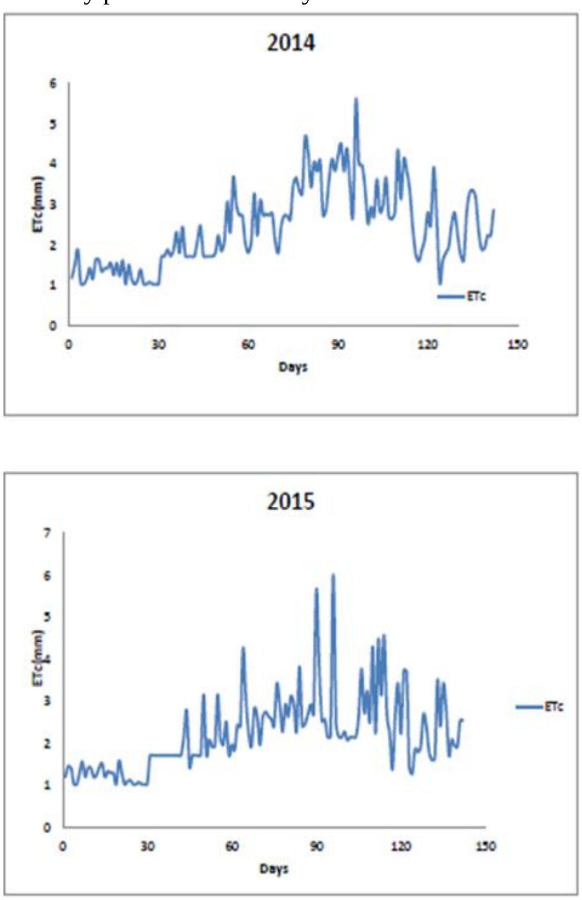
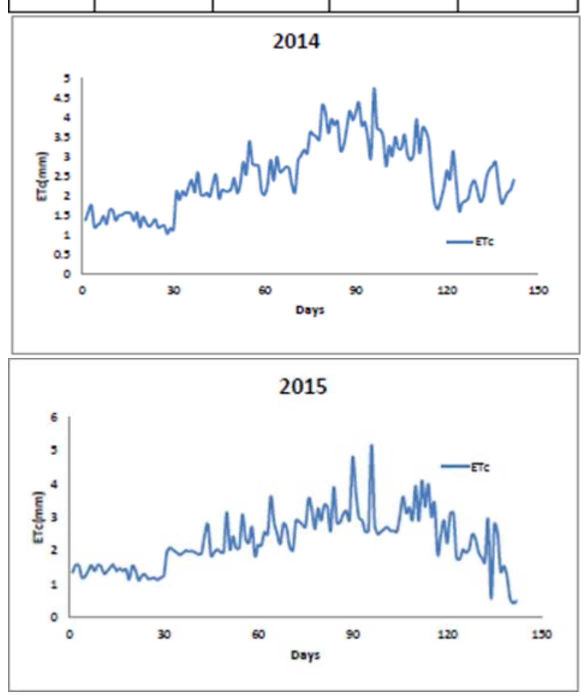


Table 2.Year wise actual evapotranspiration (mm) of Groundnut crop

Year	PET (mm)			
	Penman	Blaney-Criddle	Radiation	Pan evaporation
2014	355.46	498.35	347.02	182.5
2015	325.01	494.893	315.48	150.37



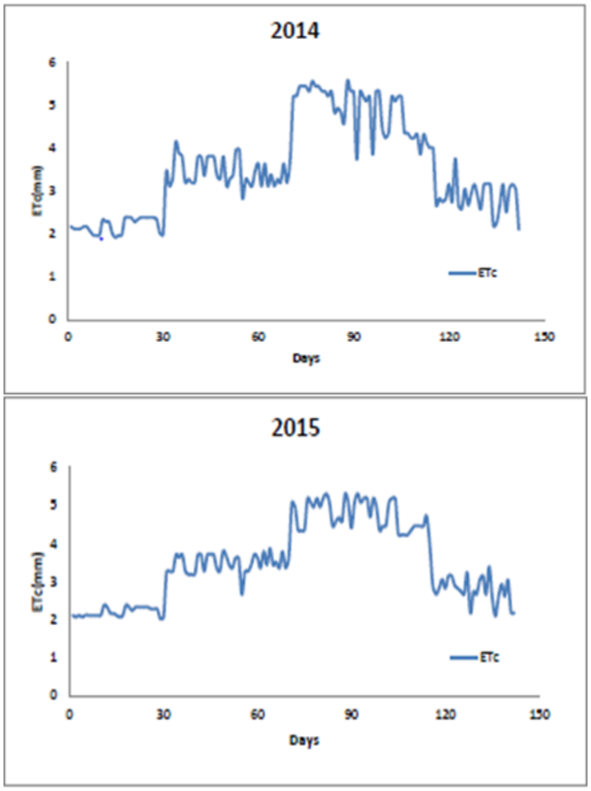
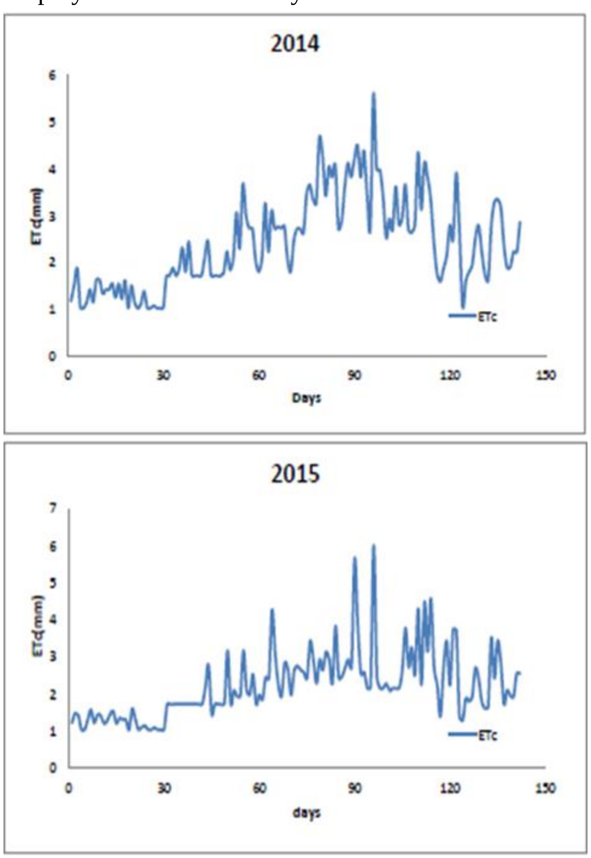


Fig 6. Daily actual evapotranspiration of Groundnut crop by Penman and Blaney – criddle method



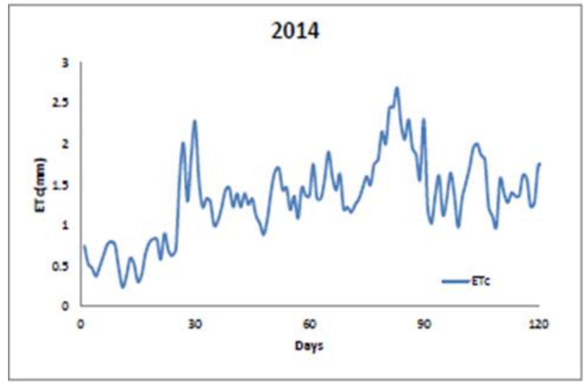


Fig. 7 Daily actual evapotranspiration of Groundnut crop by Radiation and Pan Evaporation methods

Discussions

- For the determination of crop water requirement for Kolar major crops considered are ragi and groundnut with the crop period of 120 days and 140 days respectively.
- The year wise potential evapotranspiration calculated by Blaney-criddle is maximum 645.66 mm during 2014, in this year monthly PET is maximum in july month ie 150.4mm.
- The year wise Potential evapotranspiration calculated by Penman is maximum 447.83mm during 2014, in this year monthly PET is maximum in july month ie 100.51mm.
- The year wise potential evapotranspiration calculated by Radiation method is maximum 443.3mm during 2014, monthly PET is maximum in 2014 September month ie 102.05mm.
- The year wise potential evapotranspiration calculated by Pan evaporation is maximum 236.43 mm during 2014, in this year monthly PET is maximum in july month ie 56.67mm.
- The Year wise actual evapotranspiration is also maximum during 2014 for both ragi and groundnut.
- From the above discussion we can suggest that Blaney criddle method is best suitable since it provides the most satisfactory results compared to other methods because This method is suggested for areas where available climatic data cover air temperature data only.
- It also shows Groundnut that requires more water than Ragi since growing period considered

for Ragi is 120 days and for Groundnut is 140 days.

- Estimation of evapotranspiration is one of the major hydrological components and it is very important for determining crop water requirement, scheduling irrigation at a regional level.

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