RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 10 | Issue 2 | October, 2017 | 360-366
e ISSN–0976–7223 ■ Visit us : *www.researchjournal.co.in* ■ **DOI: 10.15740/HAS/IJAE/10.2/360-366**

Weather parameter based crop planning in Tarai region of Uttarakhand

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Received : 24.04.2017; **Revised :** 29.07.2017; **Accepted :** 13.08.2017

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■ **ABSTRACT :** The major weather parameters like temperature, relative humidity, rainfall, wind speed and sunshine hour for a period of 43 years were collected and analyzed. This was done for crop planning and to develop an appropriate irrigation scheduling for different crops. The annual rainfall record indicated that in 40.47 per cent cases the normal rainfall (average ± 19%) was received in the study area, whereas, the per cent of below normal and above normal rainfall was found as 33.33 and 26.20 per cent, respectively. The highest PET was obtained in April and the lowest in December. The maximum net irrigation requirements for *Rabi* and *Kharif* season crops were found in February, March, April, June, September, October and November months. June to September months received the highest rainfall when the rainfall was received about 86 per cent of the total amount of annual rainfall. It appears that surplus rainfall (Rainfall>PET) during mid-June to August received and it can be harvested and use in high irrigation demand months.

■ **KEY WORDS :** Rainfall, Probability analysis, Irrigation water requirement, Crop planning

■ **HOW TO CITE THIS PAPER :** Vivekanand, Kumar, Vinod, Singh, Vijay Kumar and Singh, Bhaskar Pratap (2017). Weather parameter based crop planning in Tarai region of Uttarakhand. *Internat. J. Agric. Engg.*, **10**(2) : 360-366, **DOI: 10.15740/HAS/IJAE/10.2/360-366.**

Rainfall and evapotranspiration is key factor in crop production programme. The variation of monsoon and annual rainfall in space and time are well known and this inter-annual variability of monsoonal rainfall has considerable impact on agricultural production, water management and energy generation. Analysis of annual, seasonal and monthly rainfall of a region is useful to design water harvesting structure. Similarly weekly rainfall analysis gives more useful information in crop planning (Sharma *et al.*, 1979). Earlier workers have worked out the weekly rainfall probabilities for different agro climatic regions (Ray *et al.*, 1980 and Agnihotri *et al.*, 1986). Gupta *et al.* (1975)suggested that the rainfall at 80 per cent probability can safely be taken as assured rainfall, while that of 50 per cent probability is the medium limit for taking dry risk. According to Mulat *et al.* (2004) the quantum of rainfall during crop growing season and temporal distribution of rainfall is a crucial factor deciding interannual fluctuations in national crop production security.

Crop water requirement is related to weather conditions and has to be adjusted as per the atmospheric demand. For this, the United Nations Food and Agriculture Organization (FAO) have provided a method for estimating crop evapotranspiration by using reference evapotranspiration (ET_o) and crop co-efficients (K_c) (Doorenbos and Pruitt, 1997). These co-efficients depend on several factors such as type of crop, height of canopy, stage of crop growth and density (Allen *et al.*, 1998). Reference evapotranspiration (ET_o) is the rate of evapotranspiration from a hypothetical reference crop with an assumed crop height of 0.12 m, a fixed surface resistance of 70 s/m and an albedo of 0.23, closely resembling the evapotranspiration from an extensive surface of green grass uniform height, actively growing, completely shading the ground and with adequate water (Doorenbos and Pruitt, 1997). In practice, ET_o is either directly measured using lysimeter or obtained by indirect methods *i.e.*by using climatological or pan evaporation data. Several models are available for estimation of ET_o(FAO-56 PM; Allen, 1996 and Chiew *et al.*, 1995), but most of these methods are complex and require a significant number of weather parameters.Taking care future crop planning study presents a probabilityanalysis of rainfall and estimation of water requirement of different crops in Sitarganj, Udham Singh district, Uttarakhand.

METHODOLOGY

Study area :

The study was under taken in the Sitarganj, Udham Singh Nagar district which is located between 28º 45^1 N to 29º 23^{1}N latitude and laterally extends between 78º 45^1 E to 80 º 08^1 longitudes. Agriculture practices in the study area revolve around two main seasons namely *Kharif* and *Rabi*. The sowing in the *Kharif* season (summer crops) begins generally with the onset of southwest monsoon in mid-June, while the *Rabi* season (winter crops) starts with beginning of cold weather *i.e.*, by the end of the month of October or early November. The important crop grown in *Kharif* season is rice and that in the *Rabi* season is wheat. The climate in the study area varies from sub-tropical and sub-humid with three distinct seasons *i.e.* summer, monsoon (rainy season) and winter. The rainy season starts from the month of middle June to September followed by winter season, which starts from the end of October and goes upto February. The winter rains are generally experienced in late December or early January, which bring down the temperature and, therefore, December and January are the coldest months in the district. The summer season starts from March and it goes upto June. The hottest months of the year are May and June. The maximum temperature in the district goes upto 42°C during summer and minimum temperature between 1°C and 4°C. Further north of the district, the temperature comes down to 0.4°C in winter season. The average monthly rainfall varies from 13.99 mm in the month of November to 508.36 mm in month of July. About 90% of rainfall is received during the monsoon period (June to September), and remaining 10% of rainfall occurs during non-monsoon period. The index map of the study area is shown in Fig. A.

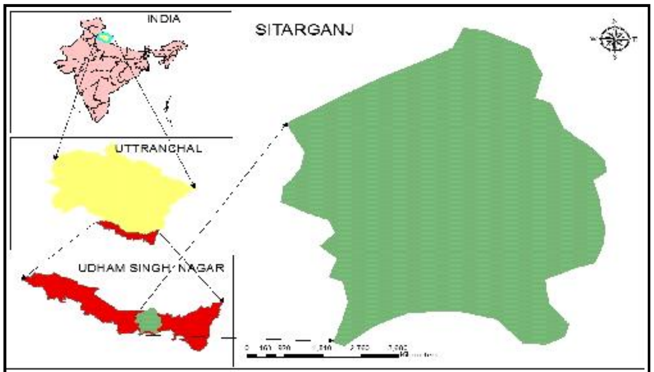

Fig. A : Location of the study area

Probability analysis of rainfall data :

The rainfall distribution analysis was conducted with suitable method among Normal, Log normal, Pearson, Log- Pearson and Gumbel distribution. The following Weibull's formula was used for calculating per cent probability:

$$P^* = \frac{m}{(N+1)} \times 100 \qquad (1)$$

where

P*= Probability of exceedence;

m = Rank number of event in the order of magnitude; and

N = Total number of year of records of data used.

Estimation of irrigation requirement of crops :

Reference evapotranspiration :

The evapotranspiration rate from a reference surface, not short of water, is called the reference crop evapotranspiration or reference evapotranspiration and is denoted as ET_o. It is calculated by FAO Monteith equation.

Crop evapotranspiration (ET_{crop}) :

The crop evapotranspiration (ET_{crop}), was calculated by multiplying reference evapotranspiration (ET_o), by a crop co-efficient(K_c).

$$ET_{crop} = ET_0 \times K_c \qquad (2)$$

where,

ET_{crop} = Crop evapotranspiration in mm/day.

Effective rainfall :

The effective rainfall (also called dependable rainfall) was calculated according to USDA Soil Conservation Service method. The formulae used in the analysis were as follows:

$$P_e = P_t \left[\frac{125 - 0.2 * P_t}{125} \right] \text{ For } P_t < 250 \text{ mm, and} \quad ...(3)$$

$$P_e = 125 + 0.1 * P_t \text{ for } P_t > 250 \text{ mm} \quad ..(4)$$

where

P_e = Effective rainfall in mm ; and

P_t = Total rainfall in mm

Net irrigation requirement :

The net irrigation requirement (NIR) of the crop was estimated by using field water balance. The variables include ET_{crop}, effective rainfall (P_{eff}), groundwater contribution (G_e) and stored soil water (W_b) as:

$$NIR = ET_{crop} - (P_{eff} + G_e + W_b) \quad ...(5)$$

where

ET_{crop} = Crop evapotranspiration;

P_{eff} = Effective rainfall;

G_e = Groundwater contribution; and

W_b = Stored soil water.

Considering no change in stored soil water before and after the crop duration and there is no contribution of groundwater and water table above the root zone.

$$NIR = ET_{crop} - P_e \quad ... (6)$$

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Probability analysis :

The study area being a part of Tarai belt, received a good amount of rainfall. The annual average rainfall in the area was 1548.29 mm, based on 43 years (1970-2012) data. About 85.75 per cent of annual rainfall was received during the rainy season (June – September) and the remaining 14.25 per cent rainfall was received as small wet spells during winter and summer seasons. The probability analysis of the weekly, monthly and annual rainfall data was carried out using DISTRIB 2.12 software. Accordingly 52, 12 and one datasets were classified for weekly, monthly and annual rainfall.Weekly, monthly and annual rainfall at different probability levels (50, 60, 70, and 80 %) along with the best fit distribution are presented in Table 1 and 2.

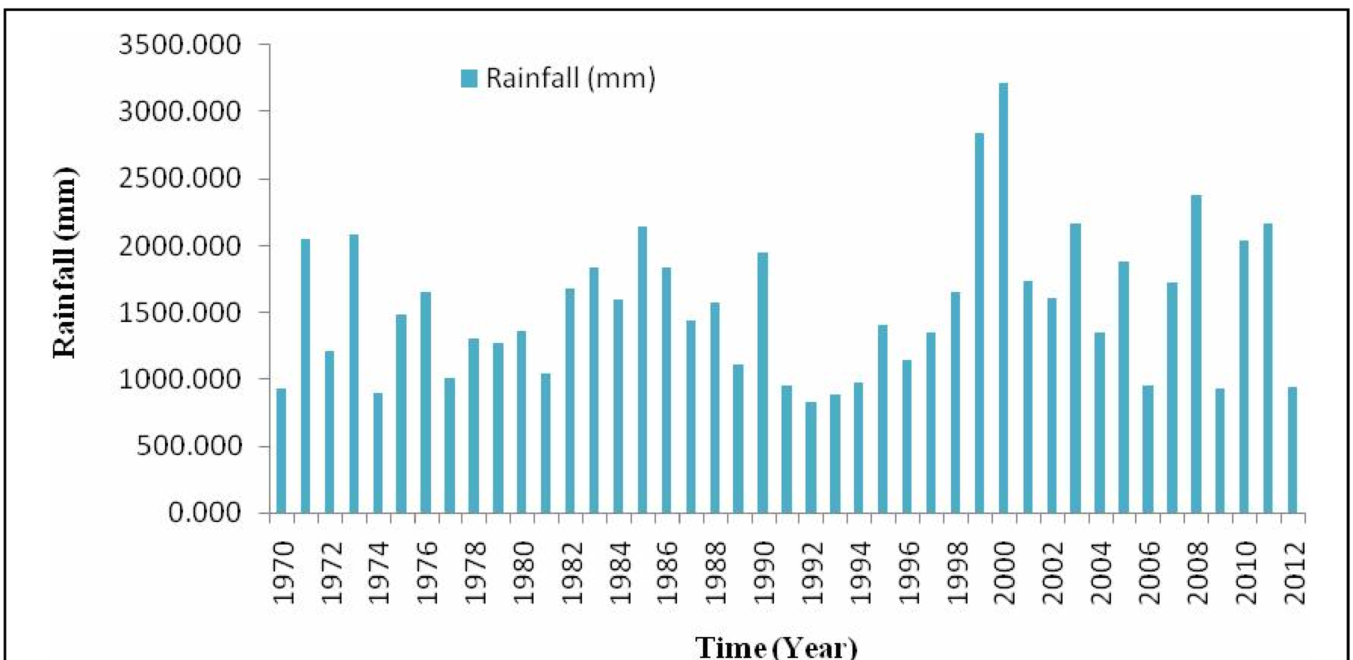

Fig. 1 : Average rainfall (1970-2012) of the study area

Table 1 : Weekly rainfall distribution at different probabilities

Standard meteorological week	Average rainfall (mm)	Predicted rainfall at probability level				Best-fit distribution
		50%	60%	70%	80%	
1	6.03	2.70	1.96	1.39	0.93	Log-Normal
2	4.75	1.32	0.88	0.57	0.34	Log-Normal
3	6.68	0.82	0.00	0.00	0.00	Pearson
4	5.48	1.43	0.00	0.00	0.00	Pearson
5	5.37	1.77	0.53	0.00	0.00	Pearson
6	11.59	3.49	0.76	0.00	0.00	Pearson
7	10.38	4.97	3.65	2.63	1.79	Log-Normal
8	7.48	2.42	1.65	1.10	0.68	Log-Normal
9	7.18	3.45	1.45	0.00	0.00	Pearson
10	5.79	2.24	0.67	0.00	0.00	Pearson
11	4.14	0.22	0.00	0.00	0.00	Pearson
12	2.63	1.34	0.99	0.73	0.50	Log-Normal
13	3.29	1.28	0.90	0.62	0.40	Log-Normal
14	2.96	1.01	0.70	0.47	0.30	Log-Normal
15	2.08	0.63	0.08	0.00	0.00	Pearson
16	4.80	1.65	1.14	0.77	0.48	Log-Normal
17	6.24	2.35	1.65	1.13	0.73	Log-Normal
18	6.47	2.04	1.39	0.92	0.57	Log-Normal
19	13.07	7.05	5.32	3.94	2.77	Log-Normal
20	20.53	7.51	5.25	3.57	2.28	Log-Normal
21	10.47	5.65	4.27	3.16	2.22	Log-Normal
22	17.47	8.51	6.29	4.54	3.10	Log-Normal
23	33.54	16.96	12.62	9.19	6.34	Log-Normal
24	44.36	25.97	19.99	15.10	10.87	Log-Normal
25	48.14	32.72	26.20	20.64	15.62	Log-Normal
26	59.64	44.35	36.50	29.63	23.21	Log-Normal
27	83.58	54.97	43.60	34.02	25.44	Log-Normal
28	112.05	84.91	70.33	57.47	45.37	Log-Normal
29	105.05	83.38	70.21	58.39	47.06	Log-Normal
30	112.75	80.29	65.18	52.13	40.13	Log-Normal
31	94.92	74.15	62.07	51.31	41.05	Log-Normal
32	90.61	66.48	54.48	44.01	34.28	Log-Normal
33	120.30	87.13	71.11	57.20	44.32	Log-Normal
34	107.23	83.58	64.57	47.30	30.79	Pearson
35	70.38	52.03	37.67	24.67	12.32	Pearson
36	87.39	55.61	38.67	24.51	12.48	Pearson
37	62.65	46.28	38.01	30.78	24.04	Log-Normal
38	59.86	25.33	11.16	0.14	0.00	Pearson
39	35.15	17.56	13.03	9.47	6.51	Log-Normal
40	14.01	5.06	3.53	2.40	1.52	Log-Normal
41	8.85	2.13	1.39	0.88	0.51	Log-Normal
42	12.34	3.16	2.08	1.33	0.79	Log-Normal
43	0.66	0.16	0.10	0.07	0.04	Log-Normal
44	1.88	0.48	0.31	0.20	0.12	Log-Normal
45	1.01	0.24	0.16	0.10	0.06	Log-Normal
46	0.57	0.10	0.06	0.04	0.02	Log-Normal
47	0.53	0.14	0.09	0.06	0.03	Log-Normal
48	1.96	0.65	0.45	0.30	0.19	Log-Normal
49	1.58	0.41	0.27	0.17	0.10	Log-Normal
50	3.68	1.06	0.71	0.46	0.28	Log-Normal
51	1.63	0.40	0.26	0.16	0.10	Log-Normal
52	7.09	2.71	1.91	1.31	0.84	Log-Normal
Total	1548.29	1012.25	786.25	598.98	441.52	

Table 2 : Monthly and annual rainfall distribution at different probabilities

Period (Month/Annual)	Average rainfall (mm)	Predicted rainfall at probability level				Best-fit distribution
		50%	60%	70%	80%	
January	28.31	20.38	16.60	13.32	10.30	Log-Normal
February	36.64	22.69	15.16	8.86	3.48	Pearson
March	15.86	10.88	7.29	4.08	1.10	Pearson
April	22.55	13.19	8.62	4.89	1.82	Pearson
May	61.54	34.94	24.46	16.42	10.45	Pearson
June	185.68	145.52	119.95	97.70	77.66	Pearson
July	508.36	513.65	466.75	415.74	354.98	Pearson
August	388.51	346.51	307.15	270.54	234.44	Pearson
September	245.05	206.38	168.50	133.06	97.83	Pearson
October	37.74	6.66	0.37	0.00	0.00	Pearson
November	4.07	1.16	0.00	0.00	0.00	Pearson
December	13.99	6.24	3.30	1.07	0.00	Pearson
Annual	1548.29	1328.2	1138.15	965.68	792.06	Log-Normal

Table 1 shows that log-normal distribution fit to weekly datasets, in most of the cases, and the annual dataset, whereas, the Pearson distribution fits well to monthly dataset (Table 2). From the 43 years dataset it was found that normal rainfall repeated itself every alternate year in most of the cases. Hence, normal rainfall was selected as for crop planning.

Potential evapotranspiration :

The highest PET observed in the month of April due tolow humidity and high temperature and the lowest in month of December. The average maximum rainfall observed in month of July and average minimum in month of November.

Irrigation water requirement :

For crop planning the normal rainfall should be used for growing paddy, wheat, sugarcane, maize, potato, barseem and cow pea crops in the study area.

It is observed that from Fig. 3 in month of June, and

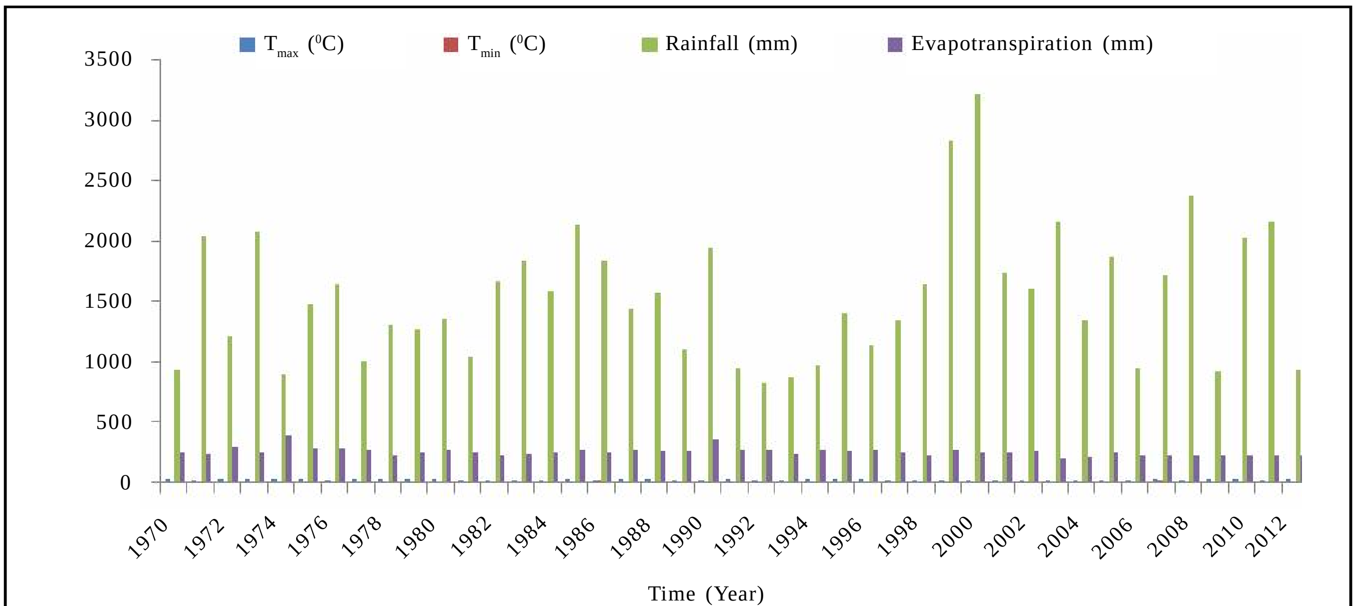

Fig. 2 : Average (Tmax, Tmin, Rainfall and Evapotranspiration) of the study

October more irrigation demand due to deficit rainfall and high evapotranspiration demand, in September month gradually less irrigation require and in month of July and August no irrigation required due to surplus excess rainfall. Irrigation demand (Fig. 4) of wheat is more in October, February and March compared to November, December and January due to deficit rainfall. Sugarcane required no irrigation (Fig. 5) in month of July and August due to surplus excess rainfall, first and last stage required less irrigation and in April, May and October month irrigation demand is more due to high atmospheric evaporation. First stage required minimal irrigation and last two month irrigation (Fig. 6) is necessary in Barseem crop. Maize crop is sensitive to both moisture stress and excessive moisture; hence regulate irrigation according to the requirement, in first month irrigation (Fig. 7) is necessary, last two month required minimal irrigation and July and August month required no irrigation due to surplus excess rainfall.

During first stage can give the surplus water (harvested water in low irrigation demand month) from excess rainfall and last two month required ensure water

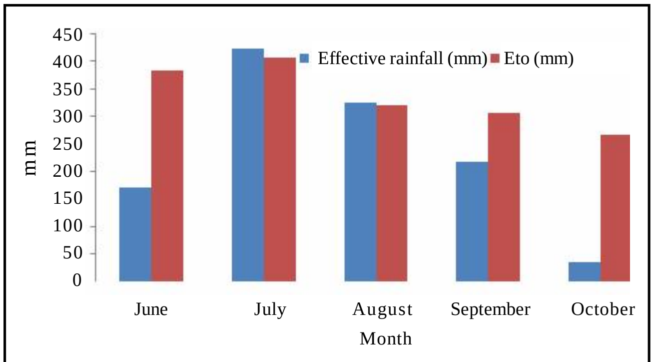

Fig. 3 : Net irrigation requirement of paddy crop

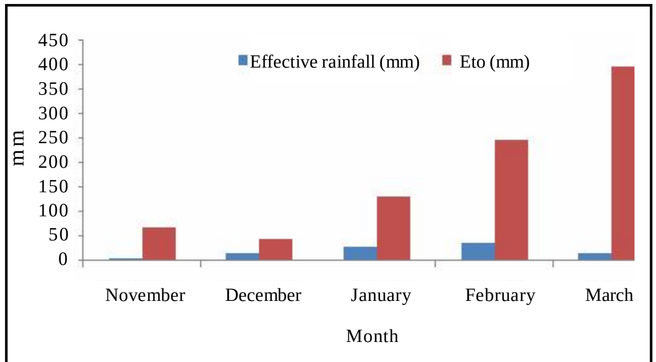

Fig. 6 : Net irrigation requirement of barseem crop

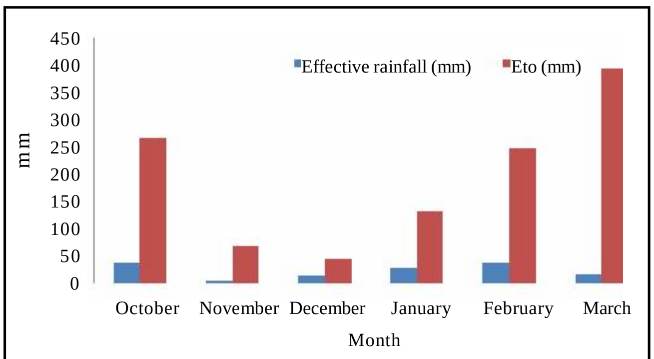

Fig. 4 : Net irrigation requirement of wheat crop

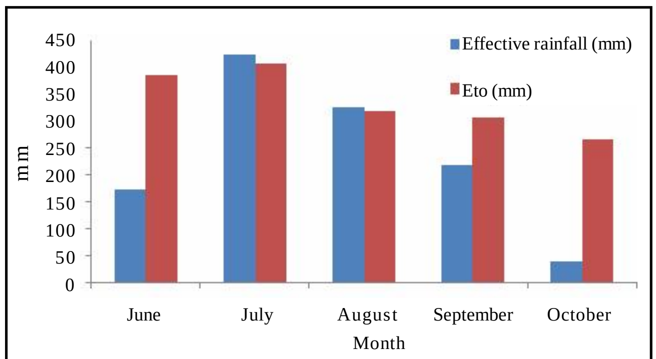

Fig. 7 : Net irrigation requirement of maize crop

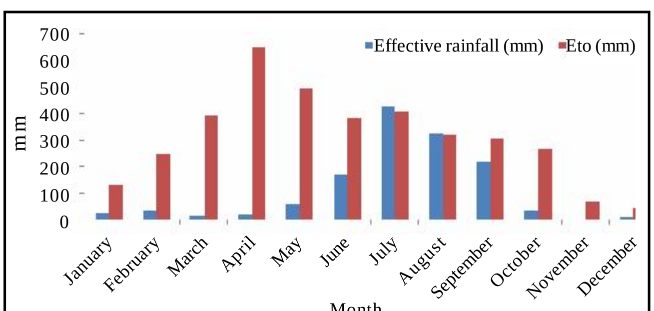

Fig. 5 : Net irrigation requirement of sugarcane crop

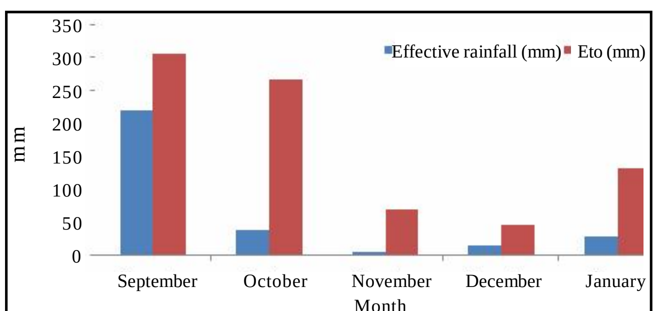

Fig. 8 : Net irrigation requirement of potato crop

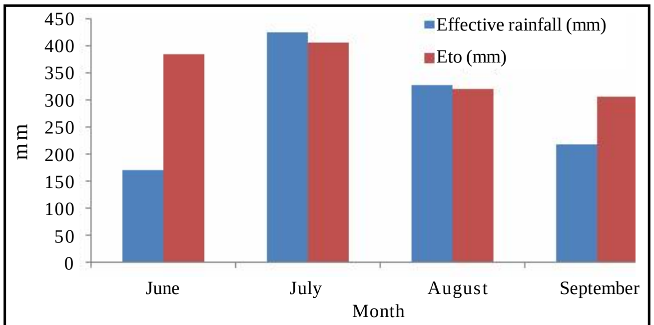

Fig. 9 : Net irrigation requirement of cowpea crop

in potato. In cowpea approximately irrigation demand is same in whole crop period except the first month.

Conclusion :

Rainfall and evapotranspiration are vital parameter for crop planning in any region. About 86 per cent rainfall occurred during June to September month and remaining rainfall occurred as small wet spells during summer and winter season. It was found that from the dataset normal rainfall repeated itself every alternate year in most of the cases.The highest potential evapotranspiration was obtained in April and lowest in December. Water balance studies indicated that irrigation was necessary for successful *Rabi* season and *Kharif* season crop production during February, March, April, June, September, October and November due to non-availability of sufficient amount of rainfall and high atmospheric evaporativedemand of water by crops. The period between mid-June to August was found to be surplus period (rainfall>PET). The surplus water can be harvest in river, ponds, reservoir etc. and its harvested water can be used in Rabi season during high irrigation demand month September, October and November.

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■ REFERENCES

Agnihotri, Y., Madukar, R.M. and Singh, P. (1986). Weekly rainfall analysis and agricultural droughts at Chandigarh. *Vayumandal*, **16** : 54-56.

Allen, R.G. (1996). Assessing integrity of weather data for reference evapotranspiration estimation. *J. Irrig. Drain. Engg.*, **122** (2) : 97–106.

Allen, R.G., Pereira, L.S., Raes, D. and Smith, M. (1998). Crop evapotranspiration guidelines for computing crop water requirements. *FAO Irrigation and Drainage Paper no. 56, Rome, Italy.*

Chiew, F.H.S., Kamaladasa, N.N., Malano, H.M. and McMahon, T.A. (1995). Penman-Monteith, FAO-24 reference crop evapotranspiration and class-A pan data in Australia. *Agric Water Manage.*, **28** : 9–21.

Doorenbos, J. and Pruitt, W.O. (1977). Irrigation guidelines for computing crop water requirements. *Irrigation and Drainage paper* No. 24, FAO, *Rome, Italy.*

Gupta, R.K., Rambabu and Tejwani, K.G. (1975). Weekly rainfall of India for crop planning programme. *Soil Cons. Digest*, **3** : 31-39.

Liang, L., L. Li. and Liu, Q. (2010). Temporal variation of reference evapotranspiration during 1961-2005 in the Taoer river basin of Northeast China. *Agril. For. Meteorol.*, **150** : 298-306.

Liou, Y.A. and Kar, S.K. (2014). Evapotranspiration Estimation with Remote Sensing and Various Surface Energy Balance Algorithms-A Review.*Energies*, **7**: 2821-2849; doi:10.3390/en7052821.

Mulat, D., Guta, F. and Ferede T. (2004). Agricultural development in Ethiopia: are there alternatives to food aid? Research report, Addis Ababa.

Ray, C.R., Senapati, P.C. and Lal, R. (1980). Rainfall analysis for crop planning, Gopalpur (Orissa). *J. Agric. Engg.*, **17**: 1-8.

Sharma, H.C., Chauhan, H.S. and Sewa Ram (1979). Probability analysis of rainfall for crop planning. *J. Agric. Engg.*,**16** : 887-896.