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Water balance studies for the crop planning in Ranchi, Jharkhand

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सार – राँची क्षेत्र में पैदावार वृद्धि के लिए होने वाली वर्षा का परिमाण निर्धारित करने के लिए लिए पिछले 35 वर्षों के वर्षा आँकडों का विशलेषण किया गया है। सूखा वाले वर्ष में लंबे समय तक सूखे के दौर के कारण वास्तविक वाष्पीकरण से भीषण सूखा की स्थिति उत्पन्न हुई जिसने फसलों की बढ़ोतरी को बुरी तरह प्रभावित किया। सबसे अधिक अनावृष्टि वाले वर्ष के दौरान किसी प्रकार का अतिरिक्त जल नहीं पाया गया। जहाँ तक विभिन्नता गुणांक का संबंध है, जो जुलाई के महीने में 35 प्रतिशत न्यूनतम भिन्नता गुणांक अभिलेखित किया गया इसके बाद अगस्त माह में (38 प्रतिशत) जो इस माह के दौरान अपेक्षाकृत कम परिवर्तनशील रहा। भिन्नता गुणांक की प्रभाव सीमा का स्तर 50 से 100 प्रतिशत की सीमा में अप्रैल से अक्तूबर तक रहा जिससे इन महीनों में अन्य महीनों की तुलना में वर्षा पर निर्भरता की स्थिति का पता चला है। इस क्षेत्र में फसल संवर्धन की अधिकतम अवधि 28 सप्ताह और न्यूनतम अवधि 12 सप्ताह रिकार्ड की गई है। सामान्य स्थितियों में फसल संवर्धन के मौसम की अवधि 18 सप्ताह रिकार्ड की गई है। इसलिए इस क्षेत्र में अल्प अवधि वाले धान की किस्म बिरसा गोरा–101, मक्का जैसे – देवकी, गंगा–11, सुरन एवं खरीफ दालों की खेती अधिक उपर्युक्त है।

ABSTRACT. The rainfall data of 35 years was analyzed to quantify the rainfall efficiency for increased production for Ranchi region. The actual evaporation in driest year due to prolonged dry spell gives rise to severe drought condition affecting the crop growth adversely. No surplus water was recorded during driest year. In respect of coefficient of variation, the month of July registered the lowest coefficient of variation of 35 per cent followed by August (38 per cent) indicating lesser variability during this month. The threshold level of coefficient of variation ranges of 50-100 per cent was associated with April to October and indicated the dependability of rainfall in these months as compared to other months. The maximum length of growing season of 28 week, while minimum 12 week was recorded. In normal conditions, the length of growing season were recorded 18 week. Therefore, short duration paddy variety Birsa Gora-101, maize, *i.e.*, Devki, Ganga-11, Suran and kharif pulses are suitable for the region.

Key words – Rainfall, PET, Water balance, Water surplus and Water deficit.

1. Introduction

In Jharkhand, through having rich natural resources (soil, climate and biodiversities) agricultural productivity is low (1t ha^{-1}) mainly because of undulating terrain, erratic rainfall, absence of perennial and soil related constraints coupled with poor socio-economic status of the farming community. The average annual rainfall is 1459 mm in this region. The crop growing season depends not only on the rainfall distribution but also on the water holding capacity and moisture release characteristics of the soil as crop extracts stored moisture during the rainless period. Thus, crop planning based on crop water requirement estimates using weather, soil and crop parameters is essentially needed with view to manage the crops during period and minimize the risk in production. Water balance method of Thornthwaite and Mather (1955), which takes into account all these factors for estimating actual evapotranspiration have been used for this study. Computation of water requirement on weekly basis for the kharif season which covers growth period of most of the crops would exhibits clear picture of moisture deficiency and its surplus leads to better assessment of the consumptive use of water and crop planning. Crop planning for different regions have been made using this method by Jat, *et al*., 2004, Ramakrishna, *et al*., 1985, Subramanian and Sanjeev Rao, 1986 and Sanjeev Rao *et al*., 1990).

2. Material and methods

The daily rainfall for the period of 35 years of Ranchi was collected from IMD, New Delhi. The data was analyzed in the rainfall pattern in different seasons, weekly distribution, coefficient of variation and monthly rainfall. The weekly potential evapotranspiration was

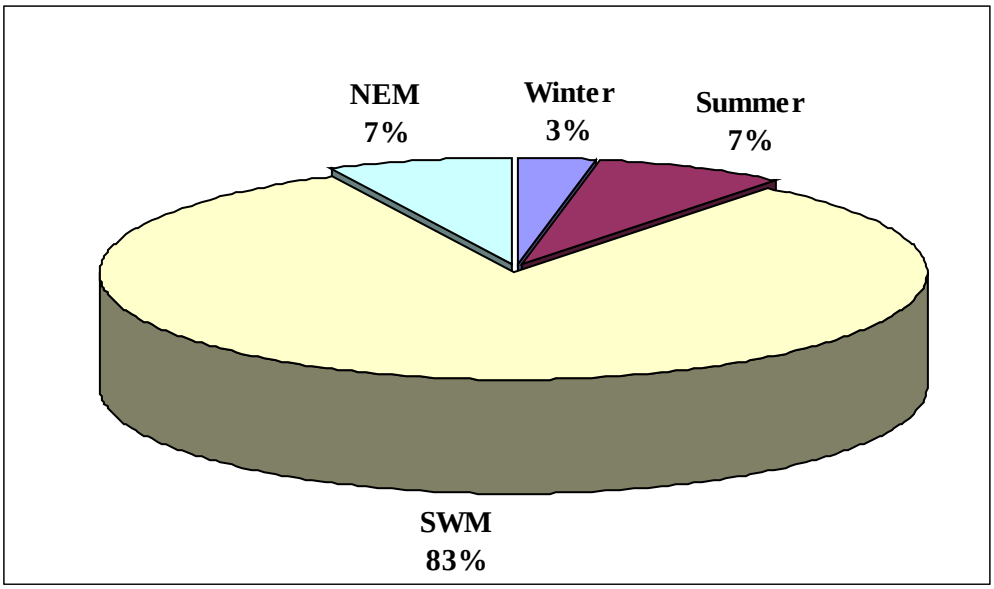

Fig. 1. Mean seasonal rainfall (in percentage of normal) of Plateau region of Ranchi (1970-2004)

TABLE 1

Comparative moisture status of Ranchi region

Years	Rainfall (mm)	Actual evapotranspiration (mm)	Water deficit(mm)	Water surplus (mm)
Normal	1459	860	894	599
Wettest	2064	850	904	1214
Driest	865	621	1133	244

calculated by Pennman-Monteith method (Allen *et al*., 1998) and weekly water balance using Thornthwaite and Mather (1955). The length of growing season was determined using moisture index method of Thornthwaite and Mather (1955).

3. Results and discussion

The mean annual rainfall of the region is 1459 mm with 28 per cent of coefficient of variation. Out of the total rainfall, 83 per cent is concentrated in kharif season. Prolonged dry spell caused due to very high evapotranspiration in driest year adversely affects crop growth and its yield. In such year, no surplus water was recorded (Table 1).

The weekly water balance analysis showed the highest rainfall (94 mm) in 30th week (Table 2). No surplus rain was observed in week during the years. The annual water need of the region has been estimated at 1754 mm against it's average annual rainfall water of 1459 mm (Table 2).

The southwest monsoon which offers higher rainfall (83 percent) and having less variability clearly indicate that successful crop production is possible with less risk during this season. To mitigate the risk rainwater harvesting is a must to provide one or two irrigation during drought period exceeding more than ten days depending upon land situation and crop also. In contrast to this, during post monsoon period rainfall variability is more and it is much below the crop water requirement.

TABLE 2

Mean weekly climatic water balance at Ranchi (1970-2004)

Weeks	PPT (mm)	PET (mm)	SM (mm)	AET (mm)	SPL (mm)	RO (mm)	DEF (mm)	AET/PET
1	1.9	23.8	1.0	2.1	0.0	0.0	21.7	0.09
2	2.6	24.4	0.9	2.7	0.0	0.0	21.7	0.11
3	4.7	25.3	0.8	4.8	0.0	0.0	20.5	0.19
4	7.2	27.1	0.7	7.3	0.0	0.0	19.8	0.27
5	4.7	28.8	0.7	4.7	0.0	0.0	24.2	0.16
6	9.0	30.6	0.7	9.0	0.0	0.0	21.6	0.30
7	8.6	32.4	0.7	8.6	0.0	0.0	23.8	0.26
8	4.8	34.7	0.9	4.6	0.0	0.0	30.1	0.13
9	8.5	36.7	1.0	8.4	0.0	0.0	28.2	0.23
10	4.6	38.7	1.2	4.4	0.0	0.0	34.3	0.11
11	4.2	40.7	1.4	4.0	0.0	0.0	36.7	0.10
12	4.6	42.0	1.5	4.5	0.0	0.0	37.6	0.11
13	7.7	43.2	1.5	7.7	0.0	0.0	35.5	0.18
14	3.9	44.4	1.7	3.7	0.0	0.0	40.7	0.08
15	3.6	45.6	1.9	3.4	0.0	0.0	42.2	0.08
16	7.7	46.8	1.8	7.8	0.0	0.0	39.1	0.17
17	8.2	47.4	1.8	8.2	0.0	0.0	39.2	0.17
18	7.9	48.3	1.8	7.9	0.0	0.0	40.4	0.16
19	9.6	49.1	1.8	9.6	0.0	0.0	39.4	0.20
20	16.0	49.9	1.6	16.2	0.0	0.0	33.7	0.32
21	16.9	48.6	1.4	17.1	0.0	0.0	31.6	0.35
22	12.0	47.7	1.5	12.0	0.0	0.0	35.8	0.25
23	29.9	46.8	1.2	30.2	0.0	0.0	16.6	0.64
24	39.6	46.0	1.0	39.7	0.0	0.0	6.2	0.87
25	80.1	43.0	38.1	43.0	0.0	0.0	0.0	1.00
26	89.1	39.7	50.0	39.7	37.5	18.8	0.0	1.00
27	69.9	36.4	50.0	36.4	33.5	26.1	0.0	1.00
28	87.7	33.1	50.0	33.1	54.6	40.4	0.0	1.00
29	90.4	29.8	50.0	29.8	60.6	50.5	0.0	1.00
30	94.6	31.3	50.0	31.3	63.3	56.9	0.0	1.00
31	81.3	31.1	50.0	31.1	50.2	53.5	0.0	1.00
32	67.5	30.8	50.0	30.8	36.7	45.1	0.0	1.00
33	81.1	30.6	50.0	30.6	50.5	47.8	0.0	1.00
34	61.2	30.0	50.0	30.0	31.3	39.5	0.0	1.00
35	75.2	29.3	50.0	29.3	45.9	42.7	0.0	1.00
36	79.0	28.7	50.0	28.7	50.3	46.5	0.0	1.00
37	70.5	28.0	50.0	28.0	42.5	44.5	0.0	1.00
38	58.7	27.9	50.0	27.9	30.8	37.7	0.0	1.00
39	39.1	27.9	50.0	27.9	11.2	24.5	0.0	1.00
40	25.1	27.9	47.3	27.8	0.0	12.2	0.1	1.00
41	21.0	27.9	41.2	27.1	0.0	6.1	0.8	0.97
42	17.4	27.9	33.4	25.2	0.0	3.1	2.7	0.90
43	10.8	26.8	24.2	19.9	0.0	1.5	6.9	0.74
44	6.9	26.0	16.6	14.5	0.0	0.8	11.5	0.56
45	4.9	25.1	11.2	10.3	0.0	0.4	14.8	0.41
46	2.8	24.3	7.5	6.5	0.0	0.2	17.7	0.27
47	3.7	23.8	5.2	6.0	0.0	0.1	17.8	0.25
48	3.3	23.3	3.6	4.8	0.0	0.0	18.5	0.21
49	0.3	22.9	2.5	1.4	0.0	0.0	21.5	0.06
50	2.3	22.4	1.9	3.0	0.0	0.0	19.4	0.13
51	2.0	22.6	1.4	2.4	0.0	0.0	20.2	0.11
52	5.0	26.5	1.2	5.3	0.0	0.0	21.2	0.20
	1459	1754		860	600	599	894	

TABLE 3

Rainfall characteristics at Ranchi region (1970-2004)

Year	Starting of growing season (week no.)	End of growing season (week no.)	Duration of growing season (weeks)	Rainfall during the growing season (mm)
1970	28	41	13	1002
1971	23	44	21	1469
1972	27	48	21	1009
1973	25	44	19	1415
1974	27	43	16	986
1975	25	43	18	1326
1976	27	39	12	1304
1977	25	52	27	1426
1978	26	48	22	1401
1979	26	48	22	663
1980	25	43	18	1106
1981	25	50	25	836
1982	23	43	20	978
1983	26	52	26	1166
1984	23	42	19	1513
1985	24	42	18	1266
1986	25	52	27	1203
1987	25	46	21	1408
1988	24	40	16	946
1989	24	52	28	1348
1990	25	45	20	1334
1991	24	52	28	1315
1992	26	42	16	982
1993	24	44	20	1071
1994	25	41	16	1577
1995	25	52	27	1813
1996	23	39	16	1520
1997	25	52	27	1924
1998	26	44	18	1406
1999	24	42	18	1776
2000	24	38	14	1005
2001	24	41	17	1066
2002	24	42	18	1141
2003	26	52	26	1349
2004	24	40	16	1007
Mean	25	45	20	1259

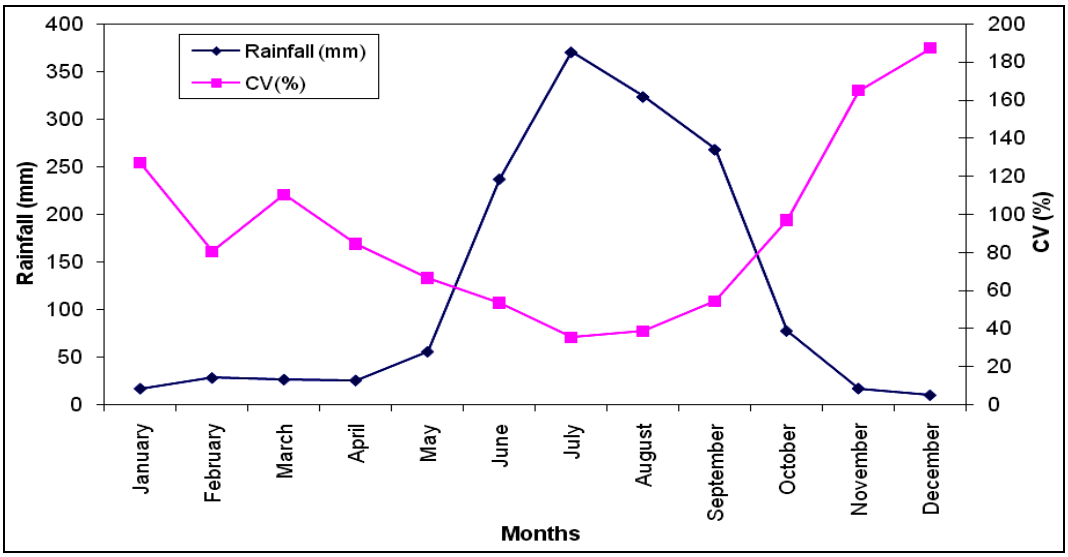

Fig. 2. Relationship between mean monthly rainfall (mm) and coefficient variation (%) of Ranchi (1970-2004)

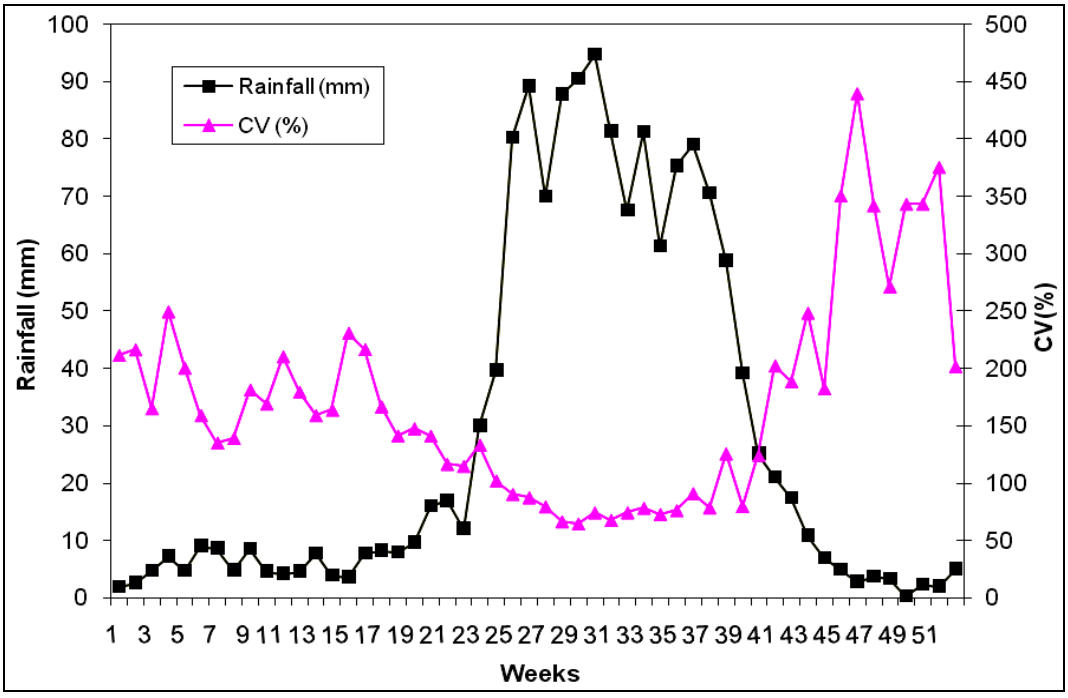

Fig. 3. Relationship between mean weekly rainfall (mm) and coefficient variation (%) of Ranchi (1970-2004)

The seasonal distribution of rainfall (Fig. 1) showed only 3 percent rain in winter and highest (83 per cent) in southwest monsoon season.

Monthly rainfall distribution showed its maximum value 370 mm (25 per cent) in July followed by 323 mm (22 per cent) in the month of August of the total annual

rainfall. Winter months received very low rain, *i.e*., 17 mm in January and 10 mm in December (Fig. 2).

Mean weekly rainfall analysis for the entire years shows more than 30 mm rainfall in weeks starting from 23rd to 39th. The lowest rainfall was recorded in 49th week. Two distinct sets of weeks evident (Fig. 3) *i.e*., from 42nd week to 22nd week having average rainfall is less than 20 mm. There is jump in rainfall amount during 23 week and it is more than 30 mm in each week upto 39 week. The 23rd week starts on June 4 which indicates the beginning of rainy season. It is clear that transition from pre monsoon to monsoon season is not well demarcated in terms of rainfall amount. From 25th to 36th week (24 June to 9 September), weekly rainfall is almost more than 80 mm. These weeks have higher probabilities for occurrence of runoff and soil loss. Coefficient of variation of rainfall computed on weekly basis is more than 100 per cent during the post monsoon *i.e*., from 40th to 24th week except in 52 week where it is les than 100 per cent and its lowest value (64 per cent) is in 29 week.

The start of growing season was from 23rd to 28th week and end of growing season was from 38th to 52nd week (Table 3). The early monsoon was 23rd week and delay monsoon was 28th week in this region. During the years having delayed onset of monsoon, the length of growing season may start as late as 28th week in the region. During the years with early withdrawal of southwest monsoon, the length of growing season ends by 38th week. Under normal conditions, the start of growing season is 25th week and end of growing season is 45 week.

The length of growing season was calculated in weeks and on an average it has been found of 20th weeks (Table 3). While in some years, it has been found a maximum of 28 weeks and minimum of 12 weeks. The normal duration of crop growing was 20th weeks. Therefore, short duration kharif crops for upland and medium duration for medium and lowlands are suitable in the region. Short duration rabi crops can be grown in medium and lowlands by utilizing residual moisture and providing minimum irrigation with harvested water.

For conditions of surplus water exceeding 40 to 100 mm the recommended varieties can be harvested successfully in the years of its occurrence and can be recycled not only to save the crop during drought period but also to raise the second crop like wheat, gram and mustard for increasing the cropping intensity and net returns from the agricultural lands.

4. Conclusions

The maximum length of growing season of 28th week, while minimum 12th week was recorded. Under normal conditions, the length of growing season was recorded 20 weeks. Therefore, short duration paddy variety Birsa Gora-101, maize, *i.e*., Devki, Ganga-11, Suran, kharif pulses are suitable for the region. For the even surplus of water exceeding 40 to 100 mm these variety can be harvested successfully in the years of its occurrence and can be recycled not only to save the crop during the periods of severe moisture stress but also to raise the second rabi crop for increasing the cropping intensity and net return from the cultivated lands. Monitoring of soil water balance every year is suggested for such probability on real basis.

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