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Study of Hundred Years Rainfall Distribution Pattern for Crop Planning in Bidar Region (Karnataka), India

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A B S T R A C T

Daily rainfall data of one hundred fifteen years (1901-2015) have been analyzed for establishing the long term averages of *nakshatra*-wise, monthly, seasonal and annual rainfall and its variability. The overall mean annual rainfall at Bidar region was 930.4 mm and distribution of 730.2 mm, 113.8 mm, 72.8 mm and 21.1 mm in monsoon, post monsoon, summer and winter respectively. The coefficient of variation of 26.6 indicated that rainfall was more or less stable over the years. July month receives maximum mean rainfall of 206.6 mm and contributed 22.2 per cent followed by September (201.4 mm, contributed 21.6 per cent). There is an ample scope for rain water harvesting from July to September which can be utilized as crop saving irrigation as well as pre sowing irrigation for succeeding *Rabi* crops which are generally sown on residual soil moisture. According to '*Nakshatras*', the traditional system of rainfall distribution for agriculture, revealed that the period from *Punarvasu* to *Swati* which covers the monsoon and post monsoon period received good amount of rainfall during which crops like Sugarcane, Maize, Bajra and pulses like Greengram, Blackgram, Soybean, Redgram can be taken up during monsoon and chick pea, Rabi sorghum, safflower can be taken up during post monsoon.

Introduction

Agriculture, especially in developing countries, is a sector which is vulnerable to risks of various types. Most importantly, weather related risks play a major role in affecting agricultural income. These would include extreme rainfall events which result in floods/droughts, as well as extreme temperature events. Poor and small farmers are especially susceptible to income variability because of weather – related risks to their crops. Rainfall, being considered as the prime input for agriculture has its own erratic behavior in terms of amount and distribution. For better crop planning, a detailed study on rainfall behaviour is vital. Rainfall variability, both in time and space influences the agricultural productivity and sustainability of a region, as opined by Virmani (1994). Bidar region of Karnataka state is predominantly a rainfed region. South west monsoon is the predominant monsoon in the region and pigeon pea and sugarcane cropping system prevails. The agricultural crop productivity largely depends on the rainfall distribution and its intensity during the rainy season. Rainfall analysis for crop planning was carried out in different regions of the country as reported by Chaudhury and

Tomar (1999); Sastri *et al.,* (1999) Sarma *et al.,* (1996); Tiwari *et al.,* (1992) and Sahoo *et al.,* (1991). In this context, an attempt was made at Krishi Vigyan Kendra, Bidar, to analyze the rainfall variability in monthly, seasonally and annually for Bidar region.

Agricultural production in India mainly depends upon the occurrence of rainfall during the cropping season. The timely onset, its distribution and sufficient monsoon rainfall is the key for better agricultural production in any part of the country which directly influences rural poverty situation (Varshneya *et al.,* 2011). There is considerable traditional knowledge of variability of rainfall patterns, since rainfed cultivation has been carried out for several centuries in India. The periods used by the farmers are however, not weeks or months but so-called *"Nakshatras"* which are 13 or 14 day periods based on solar calendar. The *Nakshatras* are constellations through which the sun passes in a year. There are 27 *Nakshatras* in a year viz., *Purvashada, Uttarabadrapada, Shravana, Danista, Purvabhadra, Uttarabhadra, Revathi, Ashwini, Bharini, Krutika, Rohini, Mrugashira, Aridhra, Punarvasu, Pushya, Aslesha, Makha, Pubba, Uttara, Hastha, Chitta, Swathi, Vishaka, Anuradha, Jyeshta* and *Moola Nakshatras.* Of these, the periods from *Rohini* to *Chitta* Nakshatras cover the monsoon season. The Nakshatra commences when the sun enters the specific constellation. Thus, the knowledge of the variability in these time units rather than weeks or months is considered important by the traditional farmers in Karnataka and other neighbouring States. The appropriate time for farming operations can also be worked out in terms of these time periods (Subash *et al.,* 2011). In order to translate the meteorological events into farmer's terminology, it is necessary to perform rainfall analysis in Nakshatra periods. De *et al.,* (2004) performed a time series analysis of rainfall on different Nakshatra periods covering Indian monsoon season. Bavadekar *et al.,* (2008) carried out *Nakshatra*-wise rainfall analysis for drought prone areas of Maharashtra. Chabbra and Haris (2014) compiled the indigenous knowledge related to climatic parameters, their forecasting during different time periods of a year (*Nakshatras*) based on experiences of the farmers and comparing indigenous knowledge with modern scientific analysis of weather data and their relationship with wheat and *rabi* maize yield in Patna, Bihar.

Materials and Methods

The daily rainfall data from Agro-meteorological Centre, Agricultural Research Station, Bidar for 115 years from 1901 to 2015 was used to analyze *Nakshatra*-wise rainfall distribution for Bidar region. Of the 27 *Nakshatras*, 12 *Nakshatras* from *Rohini* (May 25 to June 7) to *Swati* (October 24 to November 5) were considered for the analysis. The mean, standard deviation, coefficient of variation (CV%), minimum and maximum for *Nakshatra*-wise rainfall were calculated. The rainfall data were critically examined for annual, seasonal and monthly values following the procedure of Panse and Sukhatme (1985). The standard deviation (SD) and coefficient of variance (CV) of rainfall were worked out for the above periods.

Results and Discussion

Annual rainfall

The overall mean total annual rainfall of Bidar region for the past one hundred fifteen years (1901-2015) was 930.4 mm. The lowest and highest annual rainfall recorded was 417.6 mm and 1688.3 mm respectively. The standard deviation and coefficient of variation for annual rainfall was 247.3 mm and 26.6 per cent (Table 2).

Seasonal rainfall

The average seasonal rainfall and its variability during the seasons are presented in (Table 2 and Fig. 2). South west (SW) monsoon season contributes 78.5 per cent of mean annual rainfall. Rainfall during this period varied between 335.9 mm to 1522.4 mm with mean value of 730.0 mm. Total amount of rainfall received during north east (NE) monsoon was 12.2 per cent of the mean annual rainfall.

The mean rainfall during this period was 113.8 mm. Pre monsoon season (March - May) contributed 7.8 per cent (72.8 mm) of the mean annual rainfall. The winter rainfall contributed just than 1.5 per cent (13.9 mm) to the mean annual rainfall. The quantum of rainfall received during south west monsoon appears to be sufficient to raise a successful crop, however CV exceeds 30 % indicate risk in crop production because of low dependability.

However, on black soils, soybean, greengram, blackgram, redgram, sugarcane or cotton can be taken up with less risk when compared to red laterite soils which are low in water holding capacity. The CV is high during post moonsoon (87.4 %) the rabi crops like sorghum, bengalgram, safflower can be successful with one or two crop saving irrigation.

Monthly rainfall

Rainfall quantum and distribution during different months was shown in Figure 1. It is evident that monthly rainfall had bimodal peak. July month receives maximum mean rainfall of 206.6 mm followed by September (201.4 mm). The highest rainfall of 666.7 mm was reported in the July month followed by October 601.4 mm. The lowest coefficient of variation is confined to monsoon season indicating the dependability and reliability of rainfall during monsoon season (Table 1 and Fig. 1). Monthly CV is, however higher and sowing operations can commence only from last week of June to first fortnight of July.

Nevertheless, onset of monsoon of late is often delayed and is becoming more undependable. Hence, climate smart crops i.e. crops less sensitive to time of sowing like redgram, little millet, castor or desi cotton etc. could be preferred under unexpected delays.

Characterization of *nakshatra*-wise rainfall

Twelve *nakshatras* were considered for analysis because this period coincides with the crop growing period of both *kharif* and *rabi* seasons. Maximum rainfall occurred in *Pushya* (106.9 mm) followed by *Uttara* (98.2 mm) (Table 3 and Fig. 3). Rainfall was received in all *nakshatras* and good amount of rainfall was received from *Aridhra* (22 June to 5 July) to *Hasta* (27 September to 10 October). Rainfall was lowest (16.8 mm) in *Swati*. The CV of rainfall was lowest in both in Aridhra and *Uttara* (71.3 % and 72.8 % respectively) while it was highest (196.1 %) in *Chitta*. Rainfall in *Aridhra* and *Uttara* are more assured than in other *nakshatras* while it is the least assured in *Swati* and *Chitta nakshatras*. As indicated earlier sowing can commence from *Mrigashira* or *Aridhra* depending on soaking rains during *Kharif.*

The highest rainfall during Nakshatra periods are presented in Table 3. The rainfall during *Nakshatra* periods ranged from 118.6 mm to 601.4 mm. *Chitta Nakshatra* received the highest rainfall of 601.4 mm during 1962 followed by *Pushya Nakshatra* of 556.4 mm during 1970. The lowest rainfall of 118.6 mm was recorded for *Rohini* during 1943.

Table.1 Monthly mean, highest and lowest rainfall along with SD and CV as observed at Bidar (1901-2015)

Month	Lowest (mm)	Highest (mm)	Mean (mm)	SD mm/days	CV (%)	% of annual
January	0.0	77.4	6.5	15.3	237.4	0.7
February	0.0	70.3	7.4	15.2	205.2	0.8
March	0.0	121.5	15.1	24.8	164.7	1.6
April	0.0	188.7	27.0	28.8	106.4	2.9
May	0.0	294.9	30.6	40.7	132.8	3.3
June	0.0	371.8	135.9	74.6	54.9	14.6
July	25.0	666.7	206.6	117.0	56.7	22.2
August	0.0	496.0	186.1	109.6	58.9	20.0
September	29.2	525.0	201.4	107.9	53.6	21.6
October	0.0	601.4	84.1	90.8	108.1	9.0
November	0.0	300.3	24.3	43.4	178.9	2.6
December	0.0	89.7	5.5	13.3	242.2	0.6

Table.2 Characteristics of annual and seasonal rainfall as observed at Bidar (1901-2015)

Year / Seasons	Lowest (mm)	Highest (mm)	Mean (mm)	SD mm/days	CV (%)	% of annual rainfall
Annual	417.6	1688.3	930.4	247.3	26.6	100.0
Winter	0.0	81.0	13.9	21.1	152.0	1.5
Summer / Pre-monsoon	0.0	294.9	72.8	53.7	73.8	7.8
Monsoon	335.9	1522.4	730.0	220.8	30.2	78.5
Post monsoon	0.0	629.1	113.8	99.4	87.4	12.2

Annual : January – December Winter : January – February Summer : March- May
Monsoon : June - September Post monsoon: October - December
SD : Standard Deviation CV : Coefficient of variation

Table.3 Statistical characteristics of *nakshatra*-wise rainfall in Bidar

Season	*Nakshatra*	Period	Rainfall			Highest rainfall	
			Mean (mm)	SD (mm)	CV (%)	Amount (mm)	Year
Pre-monsoon	*Rohini*	May 25-Jun.7	27.7	27.9	100.7	118.6	1943
	Mrigashira	Jun.8-Jun.21	65.5	55.5	84.8	272.2	1953
Monsoon	*Aridhra*	Jun.22-Jul.5	78.9	56.2	71.3	228.6	1960
	Punarvasu	Jul.6-Jul.19	86.4	65.1	75.3	340.2	1989
	Pushya	Jul.20-Aug.2	106.9	95.7	89.6	556.4	1970
	Ashlesha	Aug.3-Aug.16	77.3	62.4	80.7	251.3	1907
	Magha	Aug.17-Aug.30	88.4	81.9	92.6	331.6	2003
	Purva	Aug.31-Sept.12	91.3	78.8	86.3	377.9	2008
	Uttara	Sept.13-Sept.26	98.2	71.5	72.8	315.0	1910
Post-monsoon	*Hasta*	Sept.27-Oct.10	55.1	65.7	119.1	322.6	2001
	Chitta	Oct.11-Oct.23	36.8	72.1	196.1	601.4	1962
	Swati	Oct.24-Nov.5	16.8	28.9	171.7	125.1	1656

Fig.1 Monthly average rainfall (mm) as recorded at Bidar

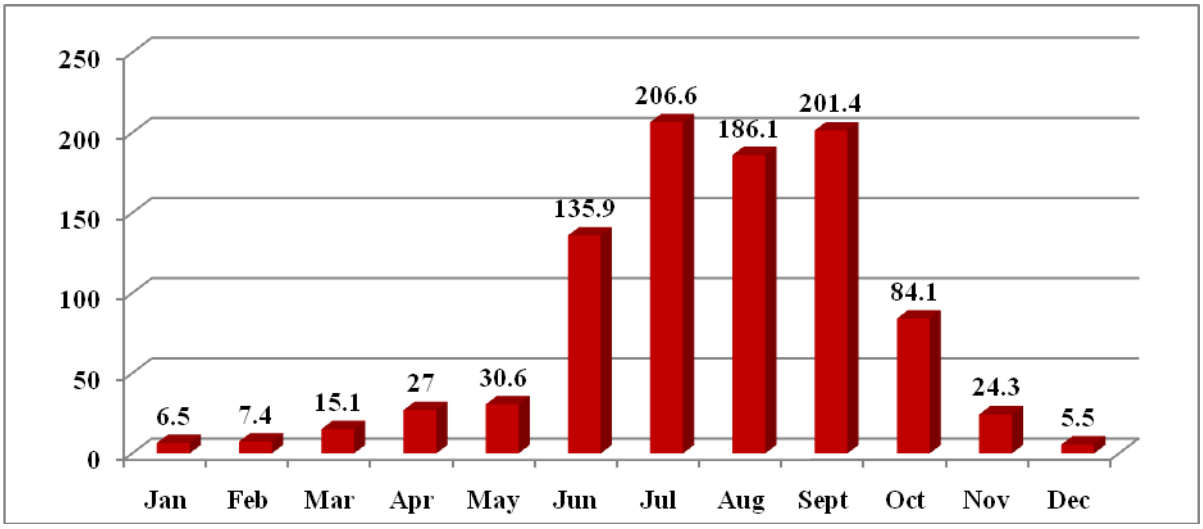


Fig.2 Average season wise rainfall (mm) as observed at Bidar

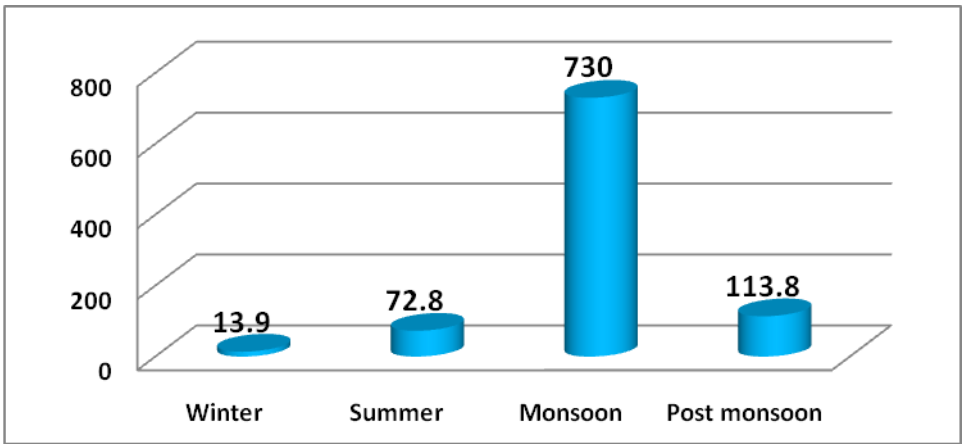
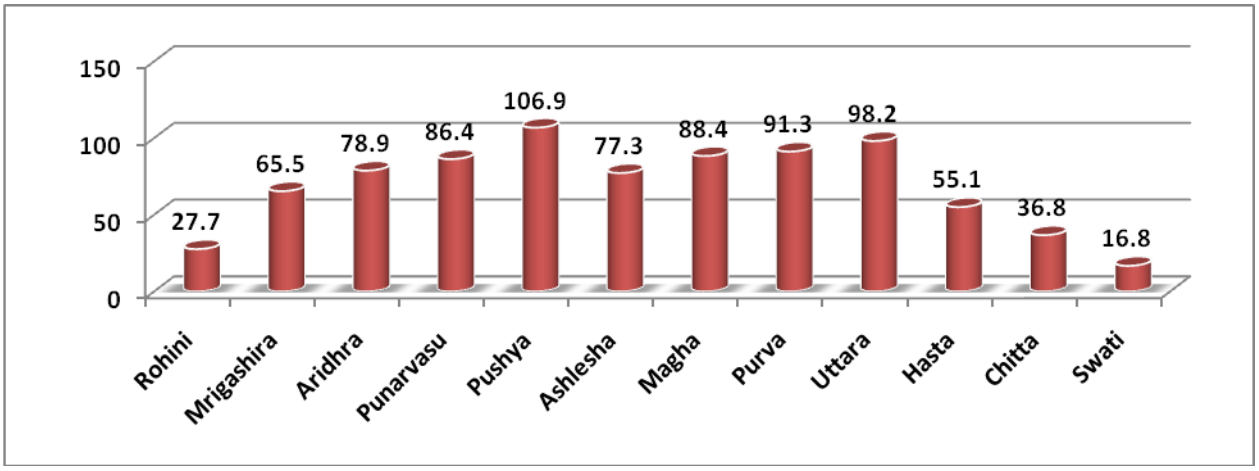


Fig.3 *Nakshatra*-wise mean rainfall (mm) of Raichur from 1901-2015



Based on the above analysis, the following recommendations for the region could be made to increase the crop production per unit area under rainfed conditions. About 78.5 per cent of the total average annual rainfall coincides with the monsoon season and is received during a short time span of two to three months between June to September due to south-west monsoon. Rainfall received during summer (March - May) season can be utilized for summer ploughing to make the land ready for final field preparation. With normal onset of rainfall, sowing of main crop like redgram + Jowar, redgram + soybean or sole sugarcane in shallow soils and redgram + blackgram /greengram in medium and deep soils can be taken up. In the event of mid-season drought, mulching will be help in reducing soil evaporation and conserving moisture in top layers of the soil. In the event of terminal drought, and under receding soil moisture conditions, crop requires supplementary irrigation.

The major portion of monsoon rainfall is generally lost through runoff which can be stored through the construction of suitable water harvesting structures as on-farm reservoirs which could be utilized for life saving irrigation for *rabi* crops.

Crop selection for rainfall in different *Nakshatra* periods

From the above analysis it is clear that the period from *Aridhra* to *Uttara* which covers the monsoon period with adequate amount of rainfall during which crops like greengram, blackgram, soybean, redgram, *kharif* sorghum, maize, bajra could be grown. With irrigation facility paddy, cotton, sugarcane, chilli can be taken up.The period from *Hasta* which received good rainfall is suitable for *Rabi* crops like chickpea sorghum, safflower. The pre-monsoon period like *Rohini*, received an average of 27.7 mm rainfall during which land preparation can be taken up.

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