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Study the rainfall variability and impact of El Nino episode on rainfall and crop productivity at Parbhani

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सार – वसंतराव नाइक मराठवाड़ा कृषि विद्यापीठ, परभणी में अभिलेखित 36 वर्षों (1981-2016) के लिए साप्ताहिक वर्षा के आंकड़ों का विश्लेषण औसत मौसमी, साप्ताहिक वर्षा और साप्ताहिक वर्षा की संभावनाओं के लिए भी किया गया। औसत मौसमी वर्षा 796 मि.मी. थी, जो बारिश के 38 दिनों में हुई है। मौसमी वर्षा ने संकेत दिया कि भिन्न-भिन्न तीव्रता के साथ 700 मि.मी. से कम वर्षा होने की संभावना 53% है और सामान्य से अधिक वर्षा होने की 36% संभावना है और मौसमी वर्षा की संभावना 11% के साथ 700 मि.मी. से 800 मि.मी. होने की है। फसल के मौसम के दौरान औसत साप्ताहिक वर्षा 116% सीवी के साथ 45.8 मि.मी. थी। उच्चतम औसत साप्ताहिक वर्षा 30वें एम डब्ल्यू में एसडी (95.3) और सीवी (132.7%) के साथ 71.8 मि.मी. दर्ज की गई। खरीफ फसलों की बुवाई 24वें एम डब्ल्यू से 27वें एम डब्ल्यू के दौरान की जानी चाहिए। सोयाबीन, हरे मटर, काले चने, हरे चने और चावल के उपज और वर्षा के बीच महत्वपूर्ण और सकारात्मक संबंध देखा गया। इस केंद्र में सभी फसलों की उत्पादकता में मौसमी वर्षा का उपयोग कर फसलों की उत्पादकता में 10-20% की भिन्नता होने का पूर्वानुमान किया गया है। अल नीनो की घटना ने दक्षिण-पश्चिमी मानसून और वार्षिक वर्षा के साथ-साथ जुलाई और सितंबर के महीनों में वर्षा को नकारात्मक रूप से प्रभावित किया। अल नीनो की घटनाएँ चावल की फसल को छोड़कर सभी फसलों की उत्पादकता पर अधिक नकारात्मक प्रभाव दिखाती हैं। अल नीनो की विभिन्न श्रेणियों में, कमजोर घटनाओं ने मध्यम और मजबूत एल नीनो घटनाओं की तुलना में छोटी अवधि की फसलों (अर्थात् सोर्घम, सोयाबीन और काले चने) की उत्पादकता पर अधिक नकारात्मक प्रभाव डाला है।

ABSTRACT. The weekly rainfall data for 36 years (1981-2016) recorded at Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani were analyzed for mean seasonal, weekly rainfall and also weekly rainfall probabilities. The mean seasonal rainfall was 796 mm, received in 38 rainy days. The seasonal rainfall indicated that there is 53% chance of receiving less than 700 mm with variable intensities and 36% chance of getting more than normal rainfall and 11% chance of seasonal rainfall, in between 700 mm to 800 mm. The mean weekly rainfall during crop season was 45.8 mm with a CV of 116%. Highest mean weekly rainfall was recorded 71.8 mm with SD (95.3) and CV (132.7%) in 30th MW. Sowing of *Kharif* crops should be undertaken during 24th MW to 27th MW. Significant and positive correlation between yield and rainfall was observed for Soybean, Pigeonpea, Black gram, Green gram and rice. The predictability of productivity of crops using seasonal rainfall is 10-20% variation in productivity for all the crops at the Centre. The El Nino episode was negatively influencing Southwest monsoon and annual rainfall as well as rainfall during the months of July and September. El Nino episodes exhibit more negative influence on productivity of all the crops except rice crop. Among the different categories of El Nino, weak events exerted more negative impact on productivity of short duration crops (*i.e.*, sorghum, soybean and Black gram) as compared to moderate and strong El Nino events.

Key words – Rainfall, Productivity, Probability analysis and El Nino episode.

1. Introduction

The water scarcity zone of Maharashtra is characterized by inadequate, ill-distributed and unpredictable rainfall. Rainfall studies particularly probability analysis is of great help in selection of crops and varieties, crop management practices, contingent crop planning, plant protection measures and related farm operations for sustained crop production in this area. Transpiration through plant parts utilizes a lot of moisture from the soil. Hence the amount of rainfall received during the life period of crop, plays an important role in the final product of the crop. It is, therefore, possible to estimate crop yields from total rainfall received during crop period (Mehta *et al.*, 2002). Thus, an attempt has been made to analyze rainfall statistics, its variability and probability and to develop yield prediction models using rainfall and productivity of important dry farming crops of the region. Weather and climate in general are the most important inputs for the agricultural production. However, in the semiarid tropics like Marathwada region of Maharashtra state, the sunshine (Radiation) and

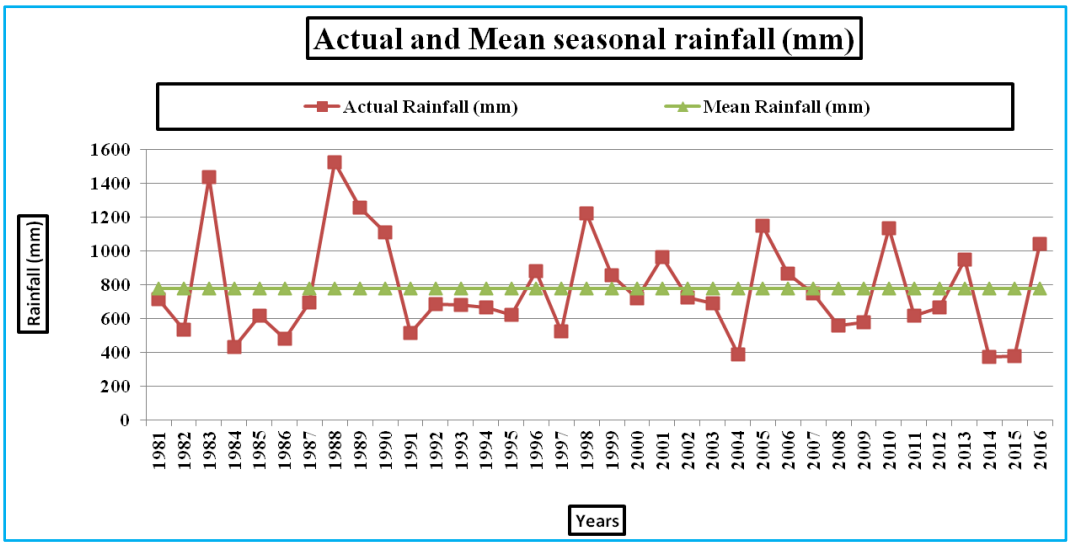

Fig. 1. Seasonal rainfall at Parbhani district of Marathwada region (1981 to 2016)

temperature are not limiting factors but the rainfall in particular under rainfed farming system is the major input, which puts the agricultural production at risk (Jadhav *et al*., 1999). The rainfed farming area is about 85 per centof the total cultivable area in Marathwada. The dependence of economy on rainfall is typified by the well-known saying that 'Budget of India is a gamble of the monsoon'. Rainfall is an important component not only for the crop production but also for horticultural crops, livestock, fisheries, forestry and other areas; such as transport, storage and marketing of agricultural produce. Food production in the country is known to be dependent on the rainfall pattern. Monsoon behavior in relation to food grain production is of major interest not only to agrometeorologists, planners and economists but also to researchers from several other disciplines since the economy of the country depends on monsoon activity and there by the resulting food production. Crop growth and yield variation can be primarily attributed to inter seasonal climatic variability in terms of changes in temperature, rainfall and input management.

2. Materials and method

The weekly rainfall data and number of rainy days recorded at the Meteorological observatory, AICRP on Agrometeorology, VNMKV, Parbhani (Latitude 19° 16' N, Longitude 76° 47' E and Altitude 409 m MSL) for the period of 1981 to 2016 (36 years) has been utilized in this study and crop data was collected from Department of Agriculture, Government of Maharashtra website (www.mahagri.gov.in) (Anonymous, 2017). Amongst the weather parameters, rainfall is an important factor in agriculture. Every drop of rainfall received during the crop growth stages has its own share in influencing the crop yields. Thus, this combined effect of rainfall on the crop yields can be studied on the basis of rainfall pattern prevailing during the crop growth stages.

The mean, standard deviation (SD) and coefficient of variation (CV%) of weekly and seasonal rainfall (from 24th to 40th Meteorological weeks) were calculated as per standard procedure. The initial probability of getting less than 15 mm, more than 15 mm, 30 mm and 45 mm were calculated by simple probability method. The correlation and regression studies were worked out using rainfall (X) as independent variable and yield (Y) as dependent variable to derive information on rainfall-yield relationship and to develop yield prediction models for important crops *viz*., Rice, pearl millet, sorghum and cotton of dry farming region (Mehta *et al.*, 2002).

The average annual, seasonal and monthly rainfall for the years with weak, strong and moderate El Niño was calculated and compared with the normal rainfall for the years 1985 to 2016 Table 1. The percentage change in seasonal rainfall during the El Niño years compared to normal rainfall was also computed for Winter season, Summer season, Southwest monsoon, Post monsoon and Annual period, in Parbhani district.

3. Results and discussion

The monsoon season, commences usually from the second week of June and withdrawal, by the end of September to early October. The rainfall data showed that the seasonal rainfall varied from 376.3 mm (2014) to over 1522.7 mm (1988) (Fig. 1) and rainy days ranged from 24 (1984, 2013 & 2015) to 60 (1988) (Fig. 3) with a mean seasonal rainfall of 778.9 mm (CV 37.9%) which is

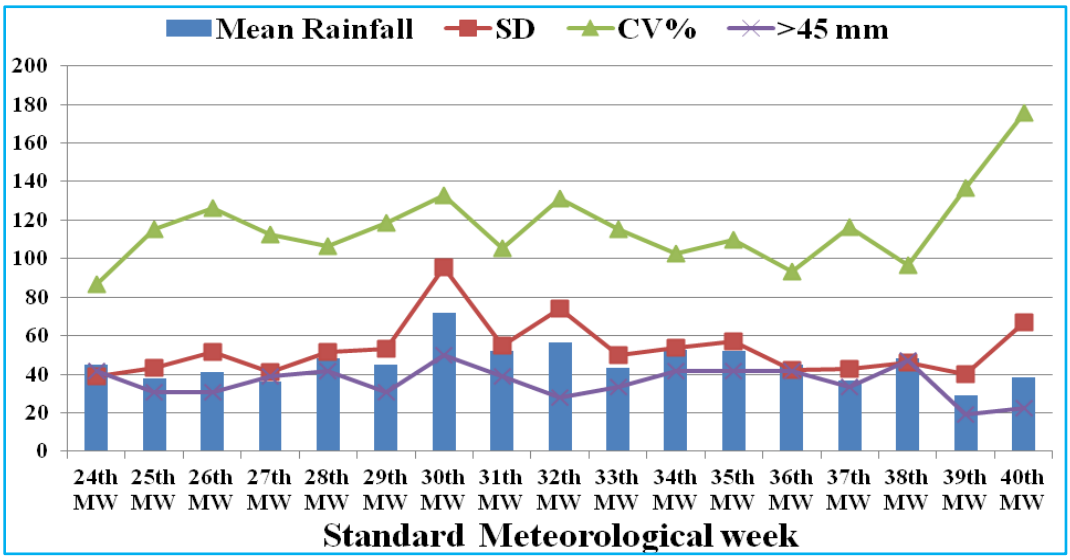

Fig. 2. Mean weekly rainfall distribution, probability, standard deviation and CV at Parbhani district of Marathwada region (1981 to 2016)

received in 38 rainy days with a CV of 23% (Dakhore *et al*., 2017 and Manyar *et al*., 2005). It is also observed that more than 1000 mm of rainfall was received after every 4 to 6 years (Fig. 1). Out of 36 years of available rainfall records, the drought years were observed to be 10 years, while excess rainfall (above average rainfall) was received in 13 years. Thus, drought appears on an average, once in three to four years with variable intensities and 36% years received rainfall more than average which also was unevenly distributed during crop season. The results of weekly rainfall statistics (Table 2) revealed that the mean weekly rainfall was more than 30 mm from 24 to 34 MW with variability ranging from 86.7 % in MW 24 to 130.9% in MW 32. The mean weekly rainfall actually varied from 29.3 to 71.8 mm of 39th MW and 30th respectively at the Center. The results also indicated that the mean weekly rainfall was 45.8 mm with a CV of 116% at Parbhani district in Maharashtra (Table 2). The last 36 years data showed that MW 30 in 2005 recorded the highest rainfall 500.3 mm in a single week (Table 2). Initial rainfall probabilities of receiving ≥45 mm rainfall in any week during the season is less than 50% indicating thereby that the rainfall at Parbhani is highly erratic in nature. The MW 30 in *Kharif* has the highest initial probability >50% of receiving >45 mm rainfall/week. Thus, sowing of *Kharif* crop could be undertaken during MW 27 at the center.

This is also confirmed by less weekly rainfall variability observed in MW 39 (Fig. 2). Similarly >45% probability of rainfall of rain is noted in MW 24, 27, 28, 30, 31 in *Kharif* which is beneficial for germination and growth of crops. However, the conditional probability of a wet week followed by a wet week (more than 30 mm/week

TABLE 1

Classification on El Niño years based on Sea Surface Temperature (SST) anomaly

Intensity	Years
Weak	2004, 2006 and 2014
Moderate	1986, 1994, 2002 and 2009
Strong	1987, 1991, 1997 and 2015
Normal	Remaining 22 years was normal

Source : Rao *et al.* (2011)

than 30 mm/week) would provide better information on optimum sowing time at a place. The distribution of rainfall within the crop period is more important than the total amount of rainfall in a season. The results of variability parameters of the productivity of different crops (Table 3) revealed that sorghum, Pigeon pea, soybean and black gram production is more or less homogeneous (30-50%), whereas there is a large variation in the yield of cotton and green gram due to erratic rainfall distribution pattern during different years. Correlation coefficient between mean rainfall with crop productivity significant and positive correlation was observed for soybean, pigeon pea, black gram, green gram and rice. The predictability of productivity of crops using seasonal rainfall is less than 20% at the center for all the crops except rice which explained 20% variation in productivity.

3.1. *Seasonal rainy days*

The data of seasonal mean actual and normal rainy days during 1981 to 2016 for parbhani district in

TABLE 2

Weekly rainfall, its variability and probability (1981 to 2016) at Parbhani

Met. Week (SMW)	Weekly rainfall statistics (mm)			Initial probability (%) of getting weekly rainfall				Maximum rainfall (mm) in a single week	
	Mean	SD	CV %	≤15 mm %	>15 mm %	>30 mm %	>45 mm %	Amount	Year
24th MW	44.8	38.9	86.7	27.8	16.7	13.9	41.7	181.8	1990
25th MW	37.9	43.6	115.1	36.1	13.9	19.4	30.6	220.8	1992
26th MW	41.0	51.8	126.3	47.2	8.3	13.9	30.6	241.5	2002
27th MW	36.4	41.1	112.7	47.2	8.3	5.6	38.9	121.6	2003
28th MW	48.2	51.4	106.6	36.1	11.1	11.1	41.7	214.9	2005
29th MW	44.7	53.1	118.8	33.3	25.0	11.1	30.6	186.7	1988
30th MW	71.8	95.3	132.7	25.0	13.9	11.1	50.0	500.3	2005
31th MW	52.3	55.0	105.2	30.6	22.2	8.3	38.9	182.1	2006
32th MW	56.4	73.8	130.9	33.3	30.6	8.3	27.7	271.2	2006
33th MW	43.1	49.7	115.2	38.9	19.4	8.3	33.3	204.8	1989
34th MW	*52.6*	*53.9*	102.6	33.3	13.9	11.1	41.7	207.7	2009
35th MW	52.2	57.1	109.5	36.1	13.9	8.3	41.7	191.6	1988
36th MW	45.2	42.0	93.1	27.8	27.8	2.8	41.7	138.8	1988
37th MW	36.9	43.0	116.6	47.2	13.9	5.6	33.3	166.5	1994
38th MW	48.0	46.3	96.5	33.3	11.1	8.3	47.2	150.6	2013
39th MW	29.3	40.1	136.8	50.0	22.2	8.3	19.4	150.2	1990
40th MW	38.2	67.1	175.7	55.6	11.1	11.1	22.2	322.8	2001
Average	45.8	53.1	116.0	37.6	16.7	9.8	36.0	-	-
SE ±	2.36	3.49	5.00	2.13	1.63	0.92	2.05	-	-

TABLE 3

Variability of crop productivity (kg/ha), correlation coefficient with rainfall and R^2 value for various crops

Parameters	Rice	Black Gram	Green Gram	Soybean	Red Gram	Cotton	Sorghum
Mean	558	351	442	1295	553	360	1098
SD	290.4	166.6	331.6	539.3	201.5	259.6	360.1
CV%	52.1	47.4	75.1	41.6	36.4	F72.2	32.8
Correlation	0.446**	0.207	0.143	0.345*	0.315*	0.394*	0.276*
R^2	0.20	0.14	0.12	0.12	0.10	0.14	0.11

*, ** Significant at 5% and 1% probability level respectively.

Marathwada region was depicted in Fig. 3. The seasonal mean rainy days and trend line showed that decreasing trend for in Parbhani. The results indicated that variation in seasonal rainy days trend observed in Parbhani and year 2002 to 2016 Actual rainy days was less as compare to normal except 2008, 2014 and 2016. It is clearly understood that the micrometeorological changes were observed intra district and intra annual and which affects on agriculture production and productivity.

3.2. *Effect of El Nino episode on rainfall (mm)*

Influence of El Niño episodes on rainfall (mm) of Parbhani districts was analyzed and calculate the percentage change in monthly, seasonal and annual rainfall of during the El Niño years compared to normal year of Parbhani districts is given in Tables 4&5. The results revealed that the average southwest monsoon and annual rainfall received during the years with El Niño was found to be less compared to normal years and the average rainfall during the post monsoon, summer and winter season is higher during El Niño years compared to normal years in Parbhani districts Table 4.

The percentage change in monthly rainfall of southwest monsoon season during the El Niño years compared to normal monthly rainfall in Parbhani

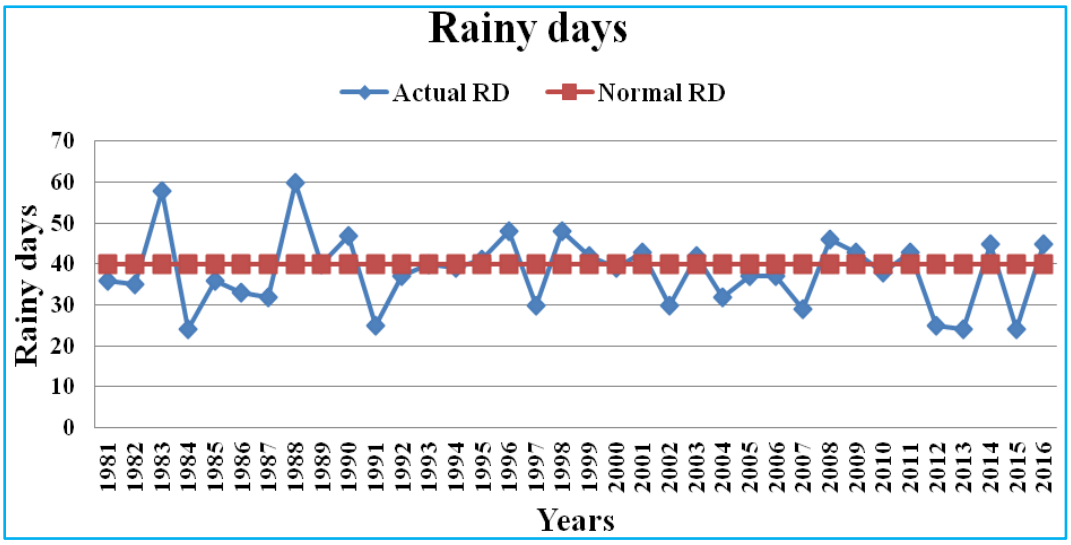

Fig. 3. Mean Actual and normal rainy days at Parbhani district of Marathwada

TABLE 4

Percentage change of seasonal and annual rainfall (mm) of parbhani

	Winter	Summer	Southwest monsoon	Post monsoon	Annual
El Nino Years (mm)	9.1	31.9	683	102.6	826.5
Normal Years (mm)	8.6	20.7	721.6	79.4	830.3
PC%	5.2	53.9	-5.3	29.2	-0.5

TABLE 5

Percentage change of monthly rainfall (mm) during monsoon at Parbhani

	June	July	August	September
El Nino Years (mm)	157.8	209.5	214.5	158.5
Normal Years (mm)	126.6	210.8	203.5	180.7
PC %	24.6	-0.6	5.4	-12.3

TABLE 6

Percentage change of productivity of *Kharif* crops under different categories of El Nino activity

Crops	Annual			Category		
				Weak	Moderate	Strong
	El Nino Years (Kg/ha)	Normal Years (Kg/ha)	PC%	PC%	PC%	PC%
Rice	540.7	528.0	2.4	-45.9	13.8	-9.0
Sorghum	862.0	1199.0	-28.1	-42.4	-11.2	-30.8
Cotton	143.1	226.5	-36.8	-21.1	-24.9	-64.5
Pigeon pea	406.5	604.6	-32.8	-40.6	-9.9	-47.8
Soybean	995.2	1243.6	-20.0	-43.3	3.8	-20.3
Black gram	202.2	408.3	-50.5	-52.8	-26.4	-43.4
Green gram	246.9	408.0	-39.5	-43.1	-23.3	-52.0

district (Table 5). The average monthly rainfall of July and September received less rainfall while in the June and August month received more rainfall during El Nino years as compared to normal years. In the Parbhani districts average monthly rainfall of July and September month received 0.6 per cent and 12.3 per cent less rainfall during El Nino years as compared to normal years.

3.3. *Effect of El Nino episode on crop productivity of major kharif crops*

The study was undertaken in the selected major crops grown in Parbhani. The Major crops of Parbhani are cotton, sorghum, soybean, black gram, green gram, pigeon pea and rice during Kharif season. In these above mentioned crops, detailed analysis was carried out to find the changes in productivity of some major crops in Parbhani districts due to El Nino episode (Table 6.). The average productivity of all the crops during *Kharif* season decreased by more than 20 per cent in Parbhani districts except Rice because area of rice crop is very less. Weak El Niño years was more negatively affected on productivity of all kharif crops, it might be due to the short duration crops like green gram, black gram, soybean, sorghum and rice was exposed for dry spells occurred in July and September months at critical growth stages of these crops. During Weak El Nino years the short duration crop was highly imparted due to soil moisture deficit at critical growth stages While Strong and moderate El Nino years the crops was not exposed to soil moisture deficit hence yield was better compare to weak El nino years. Crops are most sensitive to water deficits during the pod filling stage of development (Wesgate *et al*., 1993). A reduction in pod number, as much as 20 percent, as a result of flower abortion, is often reported as being highly affected by soil water deficits. Seeds per pod and seed size are also impacted but to a lesser extent than pod number. Stressed plants often mature earlier, shortening the grain filling period causing reduced seed weight and yield (Sionit and Kramer, 1977). Percentage change of weak El Niño years was more than 40 per cent less productivity as compare to normal years except cotton crops (-21.1).The percent change in average productivity of *kharif* crops over Parbhani district most negative impact in weak and strong El Nino years as compared to moderate El Nino years.

4. Conclusions

The seasonal rainfall indicated that there is 53% chance of less than 700 mm with variable intensities and 36% chance of getting more than normal rainfall and 11% chance of in between 700 mm to 800 mm. Total rainfall and rainy days was more fluctuation of Parbhani district and rainy days show decreasing trend. The mean weekly rainfall was 45.8 mm with a CV of 116%. Initial probabilities exceeded P = 0.5 of receiving >45 mm rainfall week was observed in 30th MW and CV 86.7% was low of 24th MW. The predictability of productivity of crops using seasonal rainfall is less than 20% at the centre for all the crops except rice. The El Nino episode was negatively influence of Southwest and annual rainfall as well as month of July and September. Weak and strong El Nino events exerted more negative impact on productivity of all the crops as compare to moderate and annual events.

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