Study on Effect of Rainfall Variability on Crop Productivity of Tur (Arhar) and Cotton Crops for Various Districts Of Maharashtra, India

ABSTRACT

This research article investigates the impact of rainfall variability on the productivity of Tur (Arhar) and Cotton crops in the districts of Maharashtra, India. The study analyzes the correlation between rainfall departure (deviation from the normal) and crop productivity, focusing on specific months when rainfall has the most significant influence on crop yield. Secondary data from the India Meteorological Department and the Ministry of Agriculture and Farmers Welfare were utilized for the analysis. Statistical methods such as detrending, correlation analysis, and significance testing were employed to measure the relationship between rainfall variability and crop productivity. For the Tur (Arhar) crop, the study covers data from 1997-1998 to 2018-2019 for 34 districts in Maharashtra. The analysis reveals the effects of rainfall on different stages of crop growth, such as sowing, germination, vegetative growth, flowering, grain formation, and harvesting. Similarly, for the Cotton crop, data from 28 districts were examined to determine the impact of rainfall on various stages of crop development. The findings indicate that rainfall plays a crucial role in crop productivity, with both positive and negative correlations observed in different districts and months. The study highlights the significance of rainfall during specific stages of crop growth and emphasizes the importance of considering rainfall patterns when making agricultural decisions. This research contributes valuable insights into the relationship between rainfall variability and crop productivity, providing farmers and policymakers with knowledge to develop sustainable agricultural strategies in Maharashtra. By understanding the influence of rainfall on crop yield, farmers can make informed decisions regarding crop selection and adopt appropriate agricultural practices to mitigate the effects of rainfall variability.

Keywords: rainfall variability, crop productivity, Maharashtra, Tur, Cotton

1. INTRODUCTION

India is a country that gambles with monsoon because of the dependability of rainfall for crop production (Mukhtar *at al.* 2020). Rainfall variability has significant implications for agricultural productivity, particularly in regions where farming is heavily reliant on rainfed irrigation. Climate change and rainfall variability both are creating a problem with crop production constraints in the rain-fed agricultural (Bedane et al. 2022). The state of Maharashtra in India experiences varying degrees of rainfall, which can have both positive and negative impacts on crop yield. This research study aims to investigate the effect of rainfall variability on the productivity of two important crops, tur (arhar) and cotton, in the districts of Maharashtra. The state of Maharashtra is in western part of India, characterized by a tropical monsoon climate with distinct hot, rainy, and cold weather seasons. The region is prone to both flood and drought situations, leading to regional inequalities in crop production. Tur (Arhar) and Cotton are widely cultivated crops in many districts of Maharashtra, making them ideal candidates for studying the relationship between rainfall and crop productivity. The objectives of this study are to understand the correlation between rainfall departure (deviation from the normal) and crop productivity, as well as to identify the specific months when rainfall has the most significant impact on crop yield for each district. Study of rainfall and its effect on crop yield is very useful for crop planning for rainfed cash crop like cotton for farmers and policy makers in rainfed agriculture (Pandya *at al.* 2020). Similarly successful drought planning is dependent on the generation of timely and accurate early warning information (Aninagyei and Appiah, 2014).

2. MATERIAL AND METHODS

2.1 Study area and crops

The Maharashtra state is the study region of present research work. The Maharashtra state lies in the western part of India. It surrounded by Goa and Karnataka states are in south, Andhra Pradesh in southeast, Gujarat state and Union Territory Dadra Nagar Haveli in northwest, Madhya Pradesh in north, Chhattisgarh and Telangana in east and Arabian sea in the west. The latitudinal and longitudinal extension of state is 15°44' North to 22°6' North latitude and 72°36' East to 80°54' East longitude. The state has 3,07,713 Sq km geographical area, with respect of area it is third largest state occupying 9.36% area of India.

Fig. 1. Illustration of Maharashtra state in India

The state has tropical monsoon climate with hot, rainy and cold weather seasons. The summer temperature varies between 22°C to 39°C in winter 12°C to 34°C. The study region receives 900 mm average annual rainfall from southwestern monsoon.

2.2 Weather and crop data

This research utilizes secondary data from various sources. Rainfall data for the study period from 1997-1998 to 2018-2019 were collected from the India Meteorological Department (https://dsp.imdpune.gov.in/), while crop data, including crop area, production, and productivity (in Tones/Hectare for Tur (Arhar) and Bales/Hectare for cotton crop), were obtained from the website of the Ministry of Agriculture and Farmers Welfare (https://www.aps.dac.gov.in/). Statistical methods such as detrending, correlation analysis, and significance testing (Student t-test) were employed to measure the relationship between rainfall variability and crop productivity. The significance of rainfall variability was assessed for different months, seasons, and annual rainfall patterns. As more than 95 per cent of the crop water requirements were fulfilled by the precipitation alone (Podaar *et.* al. 2021), the amount of rainfall received during the life period of crop, plays an important role in the final product of the crop (Dakhore *et al,* 2020).

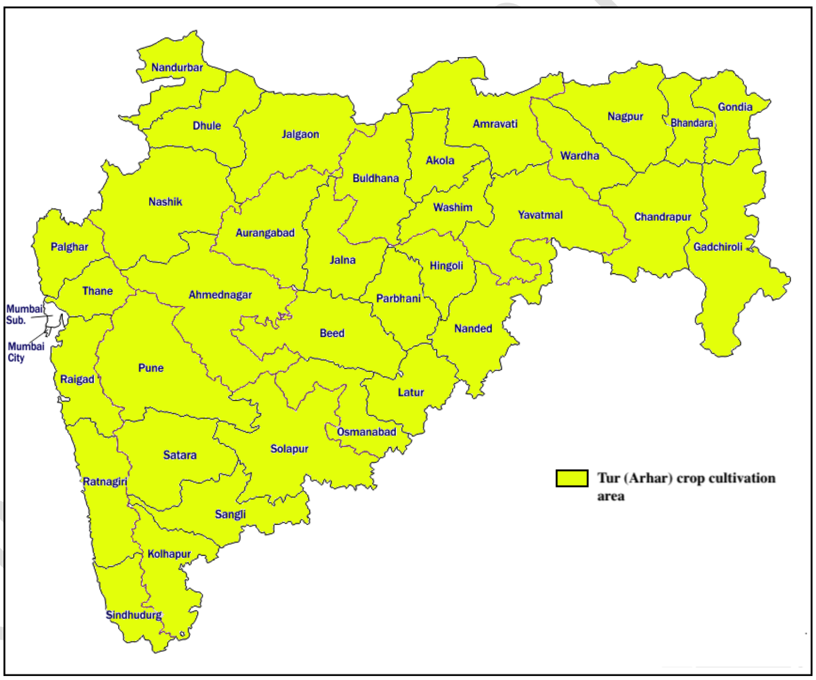

Fig. 2 Tur (Arhar) cultivating area (District) of Maharashtra

For the Tur (Arhar) crop, the data availability ranges from the start year of either 1997-98 or 1999-00 to the end year of 2018-19, depending on the district. The districts of Akola, Amraoti, C. Sambhajinagar (Aurangabad), Beed, Bhandara, Buldhana, Chandrapur, Gadchiroli, Nagpur, Wardha, Yeotmal, Jalgaon, Jalna, Latur, Nanded, Ahmednagar, Dhule, Kolhapur, Nasik, Dharashiv (Osmanabada), Parbhani, Pune, Raigad, Sangli, Satara, and

Solapur have data available for the entire period from 1997-98 to 2018-19. Gondia, Hingoli, Washim, and Nandurbar districts have data available from 1999-00 to 2018-19. Palghar district has data available from 2014-15 to 2018-19. Ratnagiri and Thane districts have data available from 1997-98 to 2016-17. Sindhudurg district has data available from 2014-15 to 2016-17.

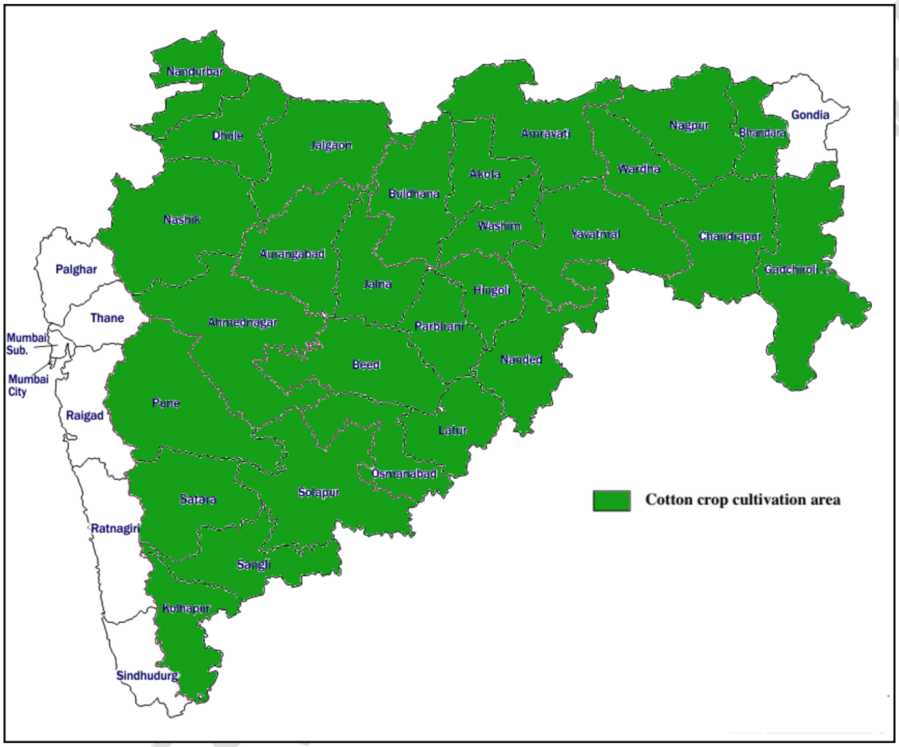

Fig. 3 Cotton cultivating area (District) of Maharashtra

The availability of crop production data of Cotton crop for different districts of Maharashtra ranges from the start year of 1997-98 or 1999-00 to the end year of 2018-19. The following districts have data available for the entire period from 1997-98 to 2018-19: Ahmednagar, Akola, Amraoti, Chhatrapati Sambhaji nagar (Aurangabad), Beed, Buldhana, Chandrapur, Dhule, Hingoli, Jalgaon, Jalna, Latur, Nagpur, Nanded, Nasik, Dharashiv (Osmanabad), Parbhani, Pune, Sangli, Satara, Sholapur, and Wardha. Bhandara district has data available from 2017-18 to 2018-19. Kolhapur district has data available from 1997-98 to 2017-18. Nandurbar district has data available from 1999-00 to 2018-19. This data availability provides valuable insights into the crop productivity trends and patterns in these districts over a significant period of time. This data availability allows for a comprehensive analysis of the relationship between rainfall variability and crop productivity for the Tur (Arhar) crop in the respective districts of Maharashtra.

2.3 Statistical analysis

2.3.1 Rainfall Departure: It is the departure of rainfall from the Normal rainfall (1961-2010). It is derived data based on actual rainfall and normal data received from the India Meteorological Department (https://dsp.imdpune.gov.in/).

2.3.2 Detrending: Detrending is removing a trend from a time series; a trend usually refers to a change in the mean over time. When you detrend data, you remove an aspect from the data that you think is causing some kind of distortion. Wu *et al*., 2007 stated that the detrending technology statistically removes the long-term mean changes from the time series. Before computing the correlation function the trend should be removed.

2.3.3 Correlation: Correlation coefficients are used to measure the strength of the relationship between two variables.

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

r	=	correlation coefficient
x_i	=	values of the x-variable in a sample
$\bar{x}$	=	mean of the values of the x-variable
y_i	=	values of the y-variable in a sample
$\bar{y}$	=	mean of the values of the y-variable

2.3.4 T test : Student's t test is used to test significance of the correlation at 95% and 99% level of significance.

$$t = \frac{m_A - m_B}{\sqrt{\frac{S^2}{n_A} + \frac{S^2}{n_B}}}$$

mA and mB represent the means of groups A and B, respectively.

nA and nB represent the sizes of group A and B, respectively.

S^2 is an estimator of the common variance of the two samples

$$S^2 = \frac{\sum (x - m_A)^2 + \sum (x - m_B)^2}{n_A + n_B - 2}$$

2.4 Crop Growth Calendars

Table 1. Crop Growth calendar for Tur (Arhar) crop

Two types of cropping patterns are followed in Maharashtra. The district wise cropping stage with respect to month during the growing season is given below.

Districts \ Month	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Akola, Amraoti C. Sambhajinagar Beed, Bhandara, Buldhana, Chandrapur, Gadchiroli Gondia, Hingoli, Nagpur, Wardha, Washim, Yeotmal	SOWING							
	GERMI-NATION							
		VEGITATIVE GROWTH						
			FLOWERING					
					GRAIN FORMATION			
						HARVESTING		

Districts \ Month	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Jalgaon, Solapur, Nanded, Sangli, Ahmednagar, Dhule, Kolhapur, Thane, Palghar, Nandurbar,Nasik, Dharashiv, Pune, Satara, Parbhani Raigad, Latur, Ratnagiri, Jalna, Sindhudurg	SOWING							
	GERMINATION							
		VEGITATIVE GROWTH						
			FLOWERING					
				GRAIN FORMATION				
						HARVESTING		

Table 2. Crop Growth calendar for Cotton crop

Four types of cropping patterns are followed in Maharashtra. The district wise cropping stage with respect to month during the growing season is given below.

Districts \ Month	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Ahmednagar, Sindhudurg Nandurbar, Buldhana, Kolhapur, Pune, Jalgaon, Thane,	SOWING							
		GERMINATION						
		VEGITATIVE GROWTH						
				FLOWERING				

Solapur, Dhule, Ratnagiri, Nasik, Palghar, Sangli, Raigad, Satara										GRAIN FORMATION						
												HARVESTING				
Month / Districts	**May**		**June**		**July**		**Aug.**		**Sept.**		**Oct.**		**Nov.**		**Dec.**	
C. S. nagar Beed, Hingoli, Jalna, Latur, Dharashiv, Parbhani	SOWING															
		GERMINATION														
			VEGITATIVE GROWTH													
						FLOWERING										
								GRAIN FORMATION								
											HARVESTING					
Month / Districts	**May**		**June**		**July**		**Aug.**		**Sept.**		**Oct.**		**Nov.**		**Dec.**	
Akola, Nanded, Washim, Yeotmal		SOWING														
			GERMINATION													
			VEGITATIVE GROWTH													
						FLOWERING										
									GRAIN FORMATION							
												HARVESTING				
Month / Districts	**May**		**June**		**July**		**Aug.**		**Sept.**		**Oct.**		**Nov.**		**Dec.**	
Amraoti, Bhandara, Chandrapur, Gadchiroli, Gondia, Nagpur, Wardha	SOWING															
			GERMINATION													
					VEGITATIVE GROWTH											
						FLOWERING										
										GRAIN FORMATION						
														HARVESTING		

3. RESULTS AND DISCUSSION

Table 3. Result of test of significance between rainfall departure and crop productivity of Tur (Arhar)

Analysis is carried out to study the correlation between rainfall departure and crop productivity for both 95 per cent and 99 per cent level of significance. Results were categorized into 6 types are given below.

N NS – Negatively Correlated and No Significance
N * - Negatively Correlated at 95 per cent level of significance
N ** - Negatively Correlated at 99 per cent level of significance
P NS – Positively Correlated and No Significance
P * - Positively Correlated at 95 per cent level of significance
P ** - Positively Correlated at 99 per cent level of significance

Month / Districts	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Ahmednagar	P *	P *	P NS	P *	P *	N NS	N NS	N NS
Akola	P *	P NS	P NS	P NS	P *	P NS	N NS	N NS
Amraoti	P *	P NS	N NS	P NS	P NS	N NS	N NS	N *
C. S. nagar	P NS	P **	P NS	P *	P *	N NS	N *	N *
Beed	P NS	P **	P NS	P **	P NS	P NS	N NS	N *
Bhandara	P NS	N NS	P NS	P NS	P NS	N NS	N *	N NS
Buldhana	P NS	P *	P NS	P NS	P NS	P NS	N NS	N *
Chandrapur	P NS	P NS	P NS	P NS	P *	P NS	N NS	N NS
Dhule	N NS	P *	P *	N NS	P NS	P *	P #	P *
Gadchiroli	P NS	P NS	P NS	P NS	P NS	N NS	N #	N NS
Gondia	N NS	N NS	N NS	P NS	P NS	N NS	N NS	N NS
Hingoli	N NS	N NS	N *	N *	N NS	N NS	N NS	N #
Jalgaon	P NS	P *	P NS	P *	P NS	N NS	N **	N NS
Jalna	P NS	P *	P NS	P *	P NS	N NS	N #	N *
Kolhapur	N NS	P *	P NS	N NS	N NS	P *	N NS	N NS
Latur	P NS	P **	N NS	P **	P **	N NS	N #	N NS
Nagpur	P NS	P NS	N NS	P NS	P NS	N NS	N *	N NS
Nanded	P **	P NS	P NS	P NS	P NS	N NS	N *	N #
Nandurbar	N NS	P NS	P NS	P NS	P NS	P **	P NS	P NS
Nasik	P NS	P NS	P **	P NS	P NS	N NS	N NS	N #
Dharashiv	P NS	P NS	P NS	P **	P NS	N *	N NS	N NS
Palghar	P NS	P NS	P NS	P NS	P NS	P NS	P NS	P NS
Parbhani	P *	P NS	P NS	P *	P *	N NS	N *	N *
Pune	P NS	P NS	P NS	P NS	N NS	P NS	P NS	N NS
Raigad	P NS	P NS	P NS	P *	P NS	P NS	N NS	N NS
Ratnagiri	P NS	P NS	N NS	P NS	P NS	P NS	N NS	N NS
Sangli	P NS	P NS	P NS	P NS	N NS	P *	N NS	N *
Satara	P NS	P NS	N NS	P NS	P NS	N NS	P NS	N NS
Sindhudurg	P NS	N NS	N NS	P NS	N *	N NS	N *	-
Sholapur	P *	P NS	P NS	P *	P NS	N NS	N NS	N NS
Thane	N NS	P NS	P NS	N NS	P NS	N NS	N NS	N #
Wardha	P *	N NS	P NS	P NS	N NS	N NS	N #	N NS
Washim	P NS	P NS	P NS	P NS	N NS	P *	N NS	P NS
Yeotmal	P **	P NS	P NS	N NS	P NS	N NS	N NS	N NS
Total	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**
(N NS)	6	5	7	4	6	20	22	22
(N *)	0	0	1	1	1	1	6	7
(N **)	0	0	0	0	0	0	1	0
(P NS)	20	20	24	19	21	8	5	3
(P *)	6	6	1	7	5	4	0	1
(P **)	2	3	1	3	1	1	0	0

As Tur (Arhar) crop is grown between June to January (Next Year) hence crop productivity (Tones/Hectare) in relation to monthly rainfall variability for a specific year across 34 districts analyzed and the following findings (Table 3) were observed:

In the month of June, no district displayed a negative correlation at a 95% level of significance, and none showed any significance at the 99% level. However, positive correlations were observed in six districts (Ahmednagar, Akola, Amraoti, Pune, Solapur, and Wardha) at a 95% level of significance, while two districts (Yeotmal and Nanded) showed significance at the 99% level. These results indicate that a substantial amount of rainfall during this month, coinciding with the crop sowing stage, leads to improved productivity.

In July, no districts exhibited a negative correlation at a 95% level of significance, and none showed significance at the 99% level. On the other hand, positive correlations were observed in six districts (Ahmednagar, Buldhana, Dhule, Jalgaon, Jalna, and Kolhapur) at a 95% level of significance, while three districts (C. S. nagar, Beed, and Latur) showed significance at the 99% level. These findings suggest that abundant rainfall in July, aligning with the germination and vegetative growth stage of the crop, contributes to enhanced productivity.

For August, one district (Hingoli) displayed a negative correlation at a 95% level of significance, while none showed significance at the 99% level. Conversely, one district (Dhule) showed a positive correlation at a 95% level of significance, and another district (Nasik) showed significance at the 99% level. This indicates that ample rainfall in August, coinciding with the vegetative growth and flowering stage of the crop, results in improved productivity in Nashik and Dhule districts, but reduces the final yield in Hingoli district.

In September, one district (Hingoli) exhibited a negative correlation at a 95% level of significance, and none showed significance at the 99% level. Conversely, positive correlations were observed in seven districts (Ahmednagar, C. S. nagar, Jalgaon, Jalna, Parbhani, Sholapur, and Raigad) at a 95% level of significance, while three districts (Beed, Latur, and Dharashiv) showed significance at the 99% level. These findings suggest that substantial rainfall in September, coinciding with the vegetative growth, flowering stage, and grain formation of the crop, leads to improved productivity in ten districts, while it reduces the final yield in Hingoli district.

In October, one district (Sindhudurg) displayed a negative correlation at a 95% level of significance, and none showed significance at the 99% level. Conversely, positive correlations were observed in five districts (Ahmednagar, Akola, C. S. nagar, Chandrapur, and Parbhani) at a 95% level of significance, while one district (Latur) showed significance at the 99% level. This suggests that substantial rainfall in October, coinciding with the flowering stage and grain formation of the crop, leads to improved productivity in six districts, while it reduces the final yield in Sindhudurg district.

In November, one district (Dharashiv) exhibited a negative correlation at a 95% level of significance, and none showed significance at the 99% level. Conversely, positive correlations were observed in four districts (Dhule, Kolhapur, Sangli, and Washim) at a 95% level of significance, while one district (Nandurbar) showed significance at the 99% level. These findings suggest that sufficient rainfall in November, coinciding with the grain formation and harvesting stage of the crop, leads to improved productivity in five districts, while it reduces the final yield in Dharashiv district.

In December, six districts (C. Sambhaji nagar, Bhandara, Nagpur, Nanded, Parbhani, and Sindhudurg) displayed a negative correlation at a 95% level of significance, and one district (Jalgaon) showed significance at the 99% level. However, no district showed a positive correlation at either the 95% or 99% level of significance. These results suggest that a significant amount of rainfall in December, coinciding with the crop harvesting stage, leads to a reduction in productivity in seven districts, while it increases the final yield in Jalgaon district.

In January, seven districts (Amraoti, C. S. nagar, Beed, Buldhana, Jalna, Parbhani, and Sangli) exhibited a negative correlation at a 95% level of significance, and no district showed significance at the 99% level. Only one district (Dhule) displayed a positive correlation at a 95% level of significance, but no district showed a positive correlation at both the 95% and 99% levels of significance. These findings suggest that a significant amount of rainfall in January, coinciding with the crop harvesting stage, leads to reduced productivity in seven districts, while it increases the final yield in Dhule district.

Table 4. Result of test of significance between rainfall departure and crop productivity of Cotton

Month / Districts	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Ahmednagar	P NS	P NS	P NS	P NS	P NS	N NS	P NS	P **	P NS
Akola	N NS	N NS	P NS	N NS	P NS	P NS	P *	P **	N NS
Amraoti	N NS	P NS	P NS	N NS	N NS	N NS	P NS	P NS	N NS
C.Sambhaji nagar	N NS	N NS	P NS	N NS	P NS	P NS	P NS	P *	N NS
Beed	P NS	N NS	N NS	P NS	P NS	P NS	P NS	P NS	P NS
Bhandara	-	-	-	-	-	-	-	-	-
Buldhana	N NS	P NS	P NS	P NS	N NS	P NS	P *	P **	N #
Chandrapur	N NS	N NS	N NS	N NS	P NS	N NS	N NS	P NS	N NS
Dhule	P NS	N *	N NS	P NS	N NS	N NS	P NS	P *	N *
Gadchiroli	P NS	N NS	N NS	N NS	N NS	P NS	N NS	N NS	-
Hingoli	N NS	P NS	N **	N **	N **	N **	N **	N **	N *
Jalgaon	P NS	N NS	N NS	P NS	N NS	N NS	P NS	P #	P NS
Jalna	N NS	P NS	P NS	N NS	N NS	P NS	P NS	P NS	N NS
Kolhapur	N NS	P *	P NS	P NS	N *	N NS	P NS	P **	P **
Latur	N NS	P NS	P NS	N NS	P **	P NS	N NS	N NS	N NS
Nagpur	N NS	N NS	P NS	N NS	P NS	P NS	P NS	P NS	P NS
Nanded	N **	N *	P NS	P NS	P NS	P NS	P *	P *	N NS
Nandurbar	P NS	N NS	P **	P NS	P NS	N NS	P NS	N NS	P #
Nasik	P NS	N NS	N NS	P NS	N NS	N NS	P NS	P NS	P NS
Dharashiv	N NS	N NS	P NS	N NS	N NS	P NS	P NS	P *	P NS
Parbhani	N NS	N *	N NS	N NS	N NS	N NS	P **	P **	P *
Pune	N NS	N NS	N NS	P NS	N **	N NS	P **	P **	N *
Sangli	P NS	P NS	P NS	P NS	N NS	N NS	P NS	P *	P #
Satara	P NS	P NS	P NS	P NS	N NS	N NS	P NS	P **	P NS

Solapur	P NS	P NS	P NS	P NS	P NS	N NS	P *	P *	P NS
Wardha	P NS	N NS	N NS	P NS	N *	P NS	P NS	P **	P NS
Washim	P NS	P NS	P NS	P NS	P NS	N NS	P NS	N NS	P NS
Yeotmal	P NS	N NS	N NS	P NS	N NS	N NS	P NS	P **	P NS
	May	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Jun.**
(N NS)	13	13	10	10	12	15	3	4	8
(N *)	0	3	0	0	2	0	0	0	3
(N **)	1	0	1	1	2	1	1	1	0
(P NS)	13	10	15	16	10	11	17	7	13
(P *)	0	1	0	0	0	0	4	6	1
(P **)	0	0	1	0	1	0	2	9	1

After analyzing the crop productivity (Tones/Hectare) in relation to monthly, seasonal, and annual rainfall for 28 districts in a particular year, the following findings (Table 4) have been observed:

As Cotton crop is grown between May to December hence crop productivity (Bales/Hectare) in relation to monthly rainfall variability for a specific year across 34 districts analyzed and the following findings (Table 3) were observed:
In May, no district showed a negative correlation at a 95% level of significance, but one district (Nanded) displayed significance at the 99% level. However, no district demonstrated a positive correlation at either the 95% or 99% level of significance. This suggests that a substantial amount of rainfall in May, which aligns with the crop sowing stage (typically done in June), leads to a reduction in the final yield in Nanded district.

In June, three districts (Dhule, Nanded, and Parbhani) exhibited a negative correlation at a 95% level of significance, while no district showed significance at the 99% level. Conversely, only one district (Kolhapur) displayed a positive correlation at a 95% level of significance, but no districts showed significance at the 99% level. These findings suggest that ample rainfall in June, coinciding with the sowing and germination stage of the crop, results in good productivity in Kolhapur district, while it reduces the final yield in the other three districts.

In July, no districts showed a negative correlation at a 95% level of significance, but one district (Hingoli) displayed significance at the 99% level. Similarly, no districts showed a positive correlation at a 95% level of significance, but one district (Nandurbar) showed significance at the 99% level. This suggests that a significant amount of rainfall in July, aligning with the sowing, germination, and vegetative growth stages of the crop, may lead to good productivity in Nandurbar district, while it reduces the final yield in Hingoli district.

In August, no districts showed a negative correlation at a 95% level of significance, but one district (Hingoli) displayed significance at the 99% level. Similarly, no districts showed a positive correlation at either the 95% or 99% level of significance. This suggests that abundant rainfall in August, coinciding with the germination, vegetative growth, and flowering stages of the crop, leads to a reduction in the final yield in Hingoli district.

In September, two districts (Kolhapur and Wardha) exhibited a negative correlation at a 95% level of significance, while two districts (Hingoli and Pune) showed significance at the 99% level. Similarly, no districts showed a positive correlation at a 95% level of significance, but one district (Latur) displayed significance at the 99% level. This suggests that ample rainfall in September, coinciding with the vegetative growth, flowering, and grain formation stages of the crop, results in good productivity in Latur district, while it reduces the final yield in the other four districts (Kolhapur, Wardha, Hingoli, and Pune).

In October, no districts showed a negative correlation at a 95% level of significance, but one district (Hingoli) displayed significance at the 99% level. Similarly, no districts showed a positive correlation at either the 95% or 99% level of significance. This suggests that adequate rainfall in October, aligning with the flowering and grain formation stages of the crop, leads to a reduction in the final yield in Hingoli district.

In November, no districts showed a negative correlation at a 95% level of significance, but one district (Hingoli) displayed significance at the 99% level. Conversely, four districts (Akola, Buldhana, Nanded, and Sholapur) exhibited a positive correlation at a 95% level of significance, while two districts (Parbhani and Pune) showed significance at the 99% level. These findings suggest that sufficient rainfall in November, coinciding with the sowing, germination, and vegetative growth stages of the crop, results in good productivity in six districts, while it reduces the final yield in Hingoli district.

In December, no districts showed a negative correlation at a 95% level of significance, but one district (Hingoli) displayed significance at the 99% level. Conversely, six districts (C. Sambhaji Nagar, Dhule, Nanded, Dharashiv, Sangli, and Sholapur) exhibited a positive correlation at a 95% level of significance, while nine districts (Ahmednagar, Akola, Buldhana, Kolhapur, Parbhani, Pune, Satara, Wardha, and Yeotmal) showed significance at the 99% level. This suggests that significant rainfall in December, aligning with the crop harvesting stage, leads to good productivity in 15 districts, while it reduces the final yield in Hingoli district. Ghanwat et. al 2022, also found the similar results, In which the significant relationship with yield of cotton lint and rainfall in Aurangabad, Jalna, Beed, Latur and Osmanabad district of marathwada region except Nanded, Parbhani and Hingoli which showed insignificant correlation.

4. CONCLUSION

In conclusion, this study highlights the significance of rainfall variability on crop productivity in Maharashtra, specifically for Tur (Arhar) and Cotton crops. It was observed that rainfall during certain months positively influenced crop yield, while dry spells during sensitive crop stages resulted in decreased productivity. Farmers in these districts should consider the rainfall patterns and stages of crop development when selecting crops and implementing appropriate agricultural practices. This research provides valuable insights into the relationship between rainfall variability and crop productivity, contributing to the development of effective strategies for sustainable agricultural production in Maharashtra.

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