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Impact of Climatic Conditions on Rice Crop of Pune Division: A Geographical Analysis

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Abstract:*The climate can thus be viewed as a mixture or aggregate of weather. Weather describes conditions of the atmosphere over a short period of time, and climate is how the atmosphere behaves over relatively long periods of time. The World Meteorological Organization (WMO), 30 years is the classical period for performing the statistics used to define climate. As a consequence, the 30-year period proposed by the WMO should be considered more as an indicator than a norm that must be followed in all cases. Climate is thus now more and more frequently defined in a wider sense as the statistical description of the climate system. This includes atmosphere, hydrosphere, lithosphere and biosphere of the interactions between them (IPCC, 2007). Climatic conditions help to shape various ecosystems and habitat around the globe. The climatic factors are impact on physical features as well as human life. It is a major role play in human environment and they also effects on his food, clothing, dwellings, and their occupations. Agriculture, our primary source of food, is critical for human survival, but its importance for the environmental climate. The agriculture system are depends on the climatic conditions and that's view presence agriculture is an uncertain. The plants and animals are affected by atmospheric conditions; it is not unreasonable that we should expect man to show effects of a similar (Robert, 1907). Agriculture and climate are two broad factors effect on crop and livestock. Climatic conditions effects on the distribution of crops, livestock and their productivity (Madhuri S., 2003). The crop growth and its productivity are declining due to increase in temperature, declining organic matter of soil and increase rate of evapotranspiration. The temperature and humidity increase in summer and winter season to increase pests, diseases and weeds. Changes in precipitation pattern increase the likelihood of short run crop failure and long run production declines (Crosson, 1997).*

Keywords:Climate, Climate Change, Crop, Productivity, Precipitation, Distribution etc.

I. INTRODUCTION

The phenomenon like climate change and its study begins German metrologist Alfred Wegener through his continental drift theory. In those circumstances, due to continental drift climate of concern continents were changed but World climatic regions are remained in their original state. But now days, considerable changes have been taken place in the present climatic conditions from their original climatic behavior. The impacts of climate change have been seen from second half of twentieth century. The global biosphere is become a sufferer directly or indirectly less or more by climate change.

The earth is a complex system continually, evolving and changing. The climate is changing and these changes are affecting the world around us. The climate system consists of several subsystems the Atmosphere, Hydrosphere, Lithosphere and Biosphere which interact to one another through both positive and negative feedback process. A change in any one of the sub-systems will turn affect the other and result in modification and changes to global climate (Talwar and Juneja, 2009). Temperature is a measure of how hot or cold the air is near earth's surface. Weather is a condition or the atmosphere at a given time and place. Crudely you can think of climate as average weather (Hussain, 2005). It will be help to clear about exactly what we mean by climate change. 'Any significant change in the pattern of climate on earth over a period of time is termed as climate change (Oxford Dictionary, 2010).

Rice is a cereal crop cultivated in wide ecological and climatic condition. The rice crop needs high humidity, prolonged sunshine and high amount of rainfall. The last three decades shows that rice production level has increased in higher latitudes while some losses have arisen in warmer areas, with temperature playing a bigger role than rainfall (Lobell, 2011). It grows in areas having tropical climate with high rainfall. The rice is a sensitive crop that depends highly on weather condition. Among the non-biotic stresses, weather plays the dominant role in influencing the growth and yield of rice. Water is not only single limiting factor but also the most important than the other weather parameters i.e., temperature and solar radiation. These factors are deeply concern to the overall growing period of rice crop in the study area.

In Pune division, rice is grown under different climatic conditions at different altitude. Rice cultivation in the study area extended from narrow strip from north to south along the crest and eastern slope of Sahyadrin Ghats (fig. 5.15). It includes hilly terrain of Pune, Satara, Sangli, and Kolhapur districts were an average altitude from 1000-2000 m. About 90 per cent rice of the study area is grown in 'Kharif' season. Recently it is observed that the frequency of severe drought and flood effects on rice production in Pune division.

II. Study Region

The Pune division is located in south-west part of Maharashtra state. It lies between 15^0 45′ N to 19^0 0′ N latitude and 73^0 32′ E to 76^0 15′ E longitudes. The area under study comprises of five districts namely Pune, Sangli, Satara, Solapur, Kolhapur and the whole division has 58 tehsils. The Pune division is bounded by the Aurangabad district to the north and NE, Thane district encircled by north and NW. The west boundary of study area delimited by Raigad, and Ratnagiri district, Sindhudurg district enclosed in south and south-west part. The south and eastern boundary surrounded by Karanataka state and eastern boundary delimited by Osmanabad district.

Physiographical this region can be divided in to three parts hilly, plateau and lowlands. Sahydri ranges passes through Pune division; its slope decreases from west to east. In this region temperature varies in the different parts, the average temperature of the study area is 25.62^0 C. An average annual rainfall in the Pune division was recorded 1239.09 mm. There is major two river basins; it includes Krishna and Bhima basins. Maximum portion of the Pune division has been occupied by these soils such as medium black, deep black and red soil where both ‘Kharif’ and ‘Rabbi’ crops are cultivating in the study area.

III. Objective

To assess an impact of climatic condition on rice crop in Pune Division

IV. Database

An essential data was collected through the primary and secondary sources. Primary data was collected according to the certain research design, which includes respondents and formulation of questionnaire, schedules, interviews, field observations and photographs. Secondary data was collected from different sources such as district gazetteers, district census handbook, socio economic abstract and toposheets (SOI). The metrological data (station-wise data of temperature and rainfall) was collected from Indian Metrological Department, Pune for the period of 1901 to 2013. The India yearly Temperature, Rainfall, Relative Humidity, Wind and Solar Radiation etc. data had been taken through the website such as www.indiawaterportal.in, www.tropomet.res.in (1901 to 2011). The drought data had taken from http://agri.gujarat.gov.in.

The agricultural data was collected from Zilla Parishad office of concern district’s as well agricultural offices, tahsil offices, Socio- economic abstract for District Statistical Department (1981 to 2011). The current decadal data was collected from www.agriculturecensus.in in 2011. The livestock data was collected from Livestock Census during 1961 to 2012 through www.livestockcensus.in . The daily milk data was achieved from www.dairy.in of the period from 2010 to 2016 of Pune Division. The 0.25^0 X 0.25^0 gridded climatic data of Pune Division had been taken from Global Weather Data website of the period of 1979 to 2013.

V. Methodology

The collected primary and secondary data were processed by using different statistical and quantitative techniques for getting correct results. During the investigation various methods were used for satisfaction of the objective.

The climatic parameters are temperature, rainfall, relative humidity, solar radiation, wind speed, crop evapotranspiration, frost, cloud condition, wet day frequency, water vapor frequency trend processed by using MS-Excel Windows office 2010.

The Potential Evapotranspiration calculated with the help of Thornwait's method (1948) as follows:

$PE = 1.6\ (10\ t / I)^a$

Where, e = monthly unadjusted (PE) in cm/month.

t = mean monthly temp in ^{0} C

I = annual heat index ($\sum$ I)

I = monthly heat index is equal to $(t/5)^{1.514}$

a = non-linear function of heat index, approximated expression,

$a = (0.000000675 * I^3 – 0.0000771* I^2 + 1.7921* I + 0.49239)$

Unadjusted PE (e) – obtained is for average 12 hours sunshine and 30-day month.

The Moisture Index studies were carried out with the help of Thornwait and Marther (1955) formula. This is as following:

Humidity Index (Ih) = WS / PE * 100

Aridity index (Ia) =WD / PE *100

Moisture Index (Im) = Ih - Ia

Whereas, PE = Potential Evapotranspiration

AE = Actual Evapotranspiration

WS = Water Surplus

WD = Water Deficient

Water Surplus=the sum of the monthly difference between precipitation (P) and ETp for those months;
When P exceeds PE (cm)

Water Deficiency=the sum of the monthly difference between ETp and precipitation (P) for those months;
When PE exceeds P (cm)

An aridity of a region is measured with applying the method of De Martone Aridity Index (1925) method:

$I_{DM} = P / T + 10$

Whereas, P=Average annual rainfall.

T= Average annual temperature in ^{0}C

The Nath and Deka (2002): For normal deviation estimation and analyzing the year as drought, normal and excessive following formula was used:

ND = (x – m) / m

Whereas, ND=Normal deviation.

x = is the total rainfall for each year.

m= is the average rainfall.

The yearly rainfall is also classified as drought, excessive and normal rainfall years when particular year receives rainfall less than Xy-S, more than Xy+S and between Xy-S and Sy+5 respectively where, Sy is the mean rainfall of year and 3 represents the standard deviation of yearly rainfall.

VI. Climate Condition of Rice Producing Areas in Pune Division

The Table No. 1.1 shows the weather calendar of rice crop, which helps to knowing the growing period of rice (June to October) in Pune division. It is observed that the rice crop is totally dependent on monsoonal climatic condition of the study area.

Rainfall

There is need of ample rainfall for rice crop. The Pune division has average 2000 mm per annum. The results of Table No. 1.1 showed that the rainfall with standard deviation was found to be more during July (598.12 ± 114.66) and it was followed by August, June, September and October (169.07 ± 57.40) months. The coefficient of variation of rainfall ranges from 19.00to 57.40 per cent during the rice crop growing season. An average rainfall during the June to October is more than 2500 mm especially in rice producing areas in Pune division. The maximum amount of rainfall is in the months of June and July and it decreases after September month.

Temperature

The maximum temperature was found to be with standard deviation from the month of October (29.31 ±1.45), followed by June, September, July and lowest maximum temperature in month of August (23.54 ± 0.97). The coefficient of variation of maximum temperature ranges from 2.54 to 6.84 for rice growing season. The minimum temperature was found to be with standard deviation from the month of June (21.93 ± 0.34), it was followed by July to September and lowest minimum temperature is observed in October (18.58 ± 0.73). The coefficient of variation of minimum temperature ranges from 1.49 to 3.91 for rice growing period. During the growing period of rice temperature ranges from 18°c to 30°c which is ideal for the growth of it.

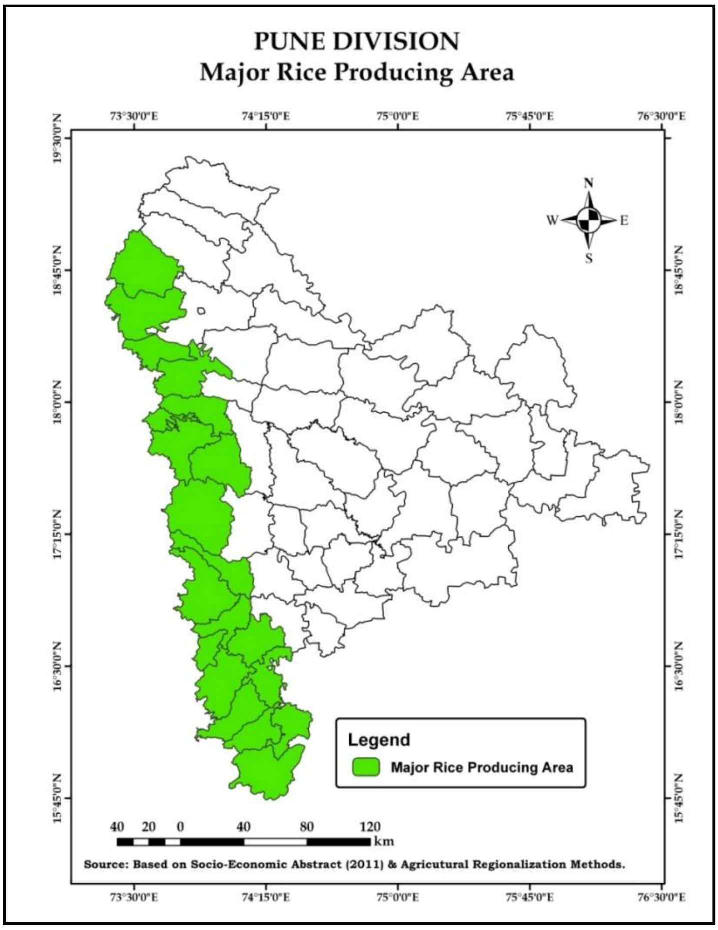

Figure 1.1

Relative Humidity

During the period 1979 to 2013, mean relative humidity was observed 88. 60 per cent for this crop in its growing period. Relative humidity was observed to be more during August (95.69 ± 1.16) followed by July, September, June and October has (75.51 ± 7.00) per cent relative humidity. The coefficient of variation of relative humidity ranges from

1.21 to 9.27 per cent over the months. The proportion of relative humidity in the atmosphere remains more than 70 per cent in all months (June to September) of growing period of rice.

Solar Radiation

The average solar radiation 12.76 MJ/M^{J2}was found during the considered period in Pune division. The results of Table No. 1.1 indicate that the frequency of solar radiation was found to be more during October (18.19 ± 1.31), and it was followed by June, September, August and July have lowest solar radiation (8.05 ± 1.93). The coefficient of variation of solar radiation ranges from 7.21 to 20.94 per cent over the months. The cloud covers are remains high during the June to August. Due to this condition at same time solar radiation observed in less amount. However, the proportion of solar radiation increases during the months of September and October which ultimately affects grain filling and maturity of rice crop.

Table1.1: Mean and Variability of Climatic Parameters for the Rice Producing Areas of Pune Division (1979-2013)

Sr. No.	Climatic Parameters	June			July			August			September			October		
		Mean	S. D.	C.V.	Mean	S. D.	C.V.	Mean	S. D.	C.V.	Mean	S. D.	C.V.	Mean	S. D.	C.V.
1	Rainfall (mm.)	481.81	122.90	25.51	598.12	144.66	24.19	507.37	96.42	19.00	349.58	128.64	36.80	169.07	97.04	57.40
2	Maximum Temperature(^{0}C)	27.56	1.88	6.84	23.67	0.60	2.52	23.54	0.94	3.98	26.18	1.12	4.28	29.31	1.45	4.94
3	Minimum Temprature^{0}C)	21.93	0.34	1.56	21.22	0.32	1.49	20.72	0.35	1.68	19.73	0.66	3.33	18.58	0.73	3.91
4	Mean Temperature(^{0}C)	24.75	1.06	4.29	22.45	0.39	1.74	22.13	0.53	2.40	22.96	0.54	2.35	23.92	0.79	3.30
5	Relative Humidity (%)	84.94	4.73	5.57	94.94	1.35	1.42	95.69	1.16	1.21	91.43	2.77	3.03	75.51	7.00	9.27
6	Solar Radiation (MJ/MJ^2)	14.26	2.60	18.20	8.05	1.93	23.94	8.11	1.94	23.90	15.20	2.59	17.04	18.19	1.31	7.21

Source: Based on the Global Weather Data (1979 to 2013)

VII. Regression Analysis of Rice

The regression statistics are shows that Table No. 1.2, 'R' value is 0.980 and it revealed that rice productivity has very highly positive relationship with climatic factors i.e., rainfall, temperature, relative humidity and solar radiations. The 'R' square value is 0.960, which is 96 per cent and adjusted 'R' Square 0.952 of the variation in rice productivity. The standard error among 35 observations is 0.181 in the regression analysis. The output for Total 34 is the sum of the information for Regression is 6 and Residual is 28. The significance value here is the probability of getting P-Value of 122.924. For factor one the significance value is 0.000 which is less than the mean value of 0.05. It is found that the rice productivity is more reliable.

The regression coefficient table no. 1.2 shows that the rice productivity is enriched by rainfall, temperature (maximum, minimum and mean), relative humidity and solar radiations. The regression equation for the above data is rice productivity = 7.781 + 0.394 (Rainfall) – 18.139 (Maximum temperature) -16.221 (Minimum temp.) + 33.236 (Mean temp.) + 0.002 (Relative Humidity) + 0.056 (Solar Radiation).

The above equation is the calculated contribution for the tested elements to attain rice productivity effectively. From the regression equation, it is observed that maximum and minimum temperature have make negative impact on crop productivity and rainfall, mean temperature relative humidity and solar radiation have shown positive impact on rice productivity. Moreover, the significance value (P-Value) which is 0.000<0.05 and it confirms the acceptance of hypothesis undertaken which means that there is direct relationship between climatic parameters and rice productivity.

While analyzing regression analysis it is found that Multiple 'R', 'R^{2}' and adjusted 'R^{2}' values are more than 0.95, hence, the productivity of rice is dependent on rainfall, temperature, relative humidity and solar radiation. Apart from this obtained significance 'F' value is 0.000 which is less than 0.05. It was reported that there is more than 0.95 per cent regression.

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Table 1.2: Variability of Climatic Parameters in the Rice Producing Area of Pune Division (1979-2013)

Months	Climatic Parameters	Rainfall (in mm)	Max. Temp. (in ^{0}C)	Mini.Temp. (in ^{0}C)	MeanTemp. (in ^{0}C)	Relative Humidity(in %)	Solar Radiation (MJ/M^{2})
June	Mean	481.81	27.56	21.93	24.75	84.94	14.26
	S. D.	122.90	1.88	0.34	1.06	4.73	2.60
	C.V.	25.51	6.84	1.56	4.29	5.57	18.20
July	Mean	598.12	23.67	21.22	22.45	94.94	8.05
	S. D.	144.66	0.60	0.32	0.39	1.35	1.93
	C.V.	24.19	2.52	1.49	1.74	1.42	23.94
August	Mean	507.37	23.54	20.72	22.13	95.69	8.11
	S. D.	96.42	0.94	0.35	0.53	1.16	1.94
	C.V.	19.00	3.98	1.68	2.40	1.21	23.90
September	Mean	349.58	26.18	19.73	22.96	91.43	15.20
	S. D.	128.64	1.12	0.66	0.54	2.77	2.59
	C.V.	36.80	4.28	3.33	2.35	3.03	17.04
October	Mean	169.07	29.31	18.58	23.92	75.51	18.19
	S. D.	97.04	1.45	0.73	0.79	7.00	1.31
	C.V.	57.40	4.94	3.91	3.30	9.27	7.21
Average	Mean	2105.95	26.05	20.44	23.24	88.51	12.76
	S. D.	117.93	1.20	0.48	0.66	3.40	2.07
	C.V.	32.58	4.51	2.39	2.82	4.10	18.06

Source: The Global Weather Data (1979 to 2013)

Table1.3: Regression Statistics of Rice

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.980
R Square	0.960
Adjusted R Square	0.952
Standard Error	0.181
Observations	35

ANOVA

	Difference	Sum of Square	Mean of Square	Frequency	Significance Frequency
Regression	6	24.113	4.019	122.924	0.000
Residual	28	1.014	0.033		
Total	34	25.127			

Source: The researcher computation through Microsoft Excel 2010

	Coefficients	Standard Error	t Stat	P-Value	Lower 95%	Upper 95%
Intercept	7.781	3.431	2.268	0.030	0.783	14.778
Rainfall (mm)	0.394	0.233	1.690	0.101	-0.081	0.869
Maximum Temp.(0C)	-18.139	8.630	-2.102	0.044	-35.741	-0.537
Minimum Temp.(0C)	-16.221	5.409	-2.999	0.005	-27.254	-5.188
Mean Temp.(0C)	33.236	13.119	2.534	0.017	6.481	59.992
Relative Humidity (%)	0.002	0.040	0.051	0.959	-0.079	0.083
Solar Radiation (MJ/MJ2)	0.056	0.543	0.102	0.919	-1.052	1.164

VIII. MATRIX CORRELATION ANALYSIS OF RICE

The rice productivity is in kg/ha and its matrix co-relation with rainfall (mm), temperature (^{0}C), relative humidity (%) and solar radiation (MJ/MJ^2). The co-efficient of co-relation showed in the Table No. 1.4, it is observed in relation of rainfall and rice productivity was 0.969. It clearly designates the very high perfect positive correlation with high significance.

Table1.4: Correlation Matrix of Climatic Indicators Influencing Rice Productivity

Sr. No.	Matrix Correlation	Productivity kg/ha	Rainfall (mm)	Maximum Temp. (^{0}C)	Minimum Temp. (^{0}C)	Mean Temp. (^{0}C)	Relative Humidity	SolarRadiation (MJ/MJ2)
1	Productivity kg/ha	1						
2	Rainfall (mm.)	0.969	1					
3	Maximum Temp.(^{0}C)	0.786	0.769	1				
4	Minimum Temp.^{0}C)	0.776	0.762	0.999	1			
5	Mean Temp.(^{0}C)	0.788	0.773	1.000	1.000	1		
6	Relative Humidity	-0.203	-0.199	-0.212	-0.210	-0.212	1	
7	Solar Radiation (MJ/MJ2)	0.436	0.387	0.879	0.880	0.875	-0.158	1

Source: The researcher computed with the help Microsoft Excel 2010

The co-relation of temperature with rice productivity is highly positive and it is observed 0.786 with maximum temperature, 0.776 with minimum temperature and 0.788 with mean temperature. The co-relation matrix between rice and relative humidity was -0.203 moderate negative values of co-efficient of correlation. The solar radiation was 0.436 and it is moderately correlated with rice productivity.

The Table No.1.4 showed correlation matrix of climatic indicators, which influences directly on the productivity of rice. It is observed that the productivity of rice is highly affected by rainfall and it is followed by temperature and solar radiation. It is observed that relative humidity is negatively very low correlated with rice yield.

IX. IMPACT OF CLIMATE CONDITION ON RICE YIELD

The results of changes in rainfall, maximum and minimum temperature, humidity and solar radiation and its impact on rice productivity have given below:

a. Annual Change

The climatic changes may directly affect rice plant growth through changes in air temperature, precipitation, relative humidity and solar radiation (Subrahmanyam, 2014). The researcher has attempted to assess the change in rainfall, maximum and minimum temperature and humidity on rice yield for 35 years 1979 to 2013. The results of rice productivity have discussed in relation to rainfall, maximum and minimum temperature, humidity and solar radiation for the period June to October of 'Kharif' season. The mean monsoonal rainfall was recorded 2105.94 mm, in 2011, the maximum rainfall was observed 2707.04 mm, whereas minimum rainfall was observed 1596.18 mm in 1992. The coefficient of variation is 16.15 and standard deviation is 340.13 mm. The average temperature for 35 years was found to be 26.05^{0}C as a maximum temperature, 20.44^{0}C minimum temperature and 23.24^{0}C mean temperature. The data shows that among the considered years the highest average maximum temperature was 27.33^{0}C observed in 1992 and the minimum temperature (19.43^{0}C) in 1985. As far as mean temperature is concerned, higher value (23.88^{0}C) was found in 2002 and lower value (22.2^{0}C) in 1990. The overall coefficient of variability was found as maximum temperature (2.60%), minimum temperature (1.74%) and mean temperature (1.83 %) with standard deviation was 0.68, 0.36, and 1.75 respectively.

During 1979 to 2013, the mean relative humidity was found 88.50 per cent. The analysis of data showed that maximum 93 per cent humidity in 1990 and minimum relative humidity 85 per cent was found in the years 1985 and 2002. The overall coefficient of variability in relative humidity was 1.83 per cent with standard deviation 2.02. The mean solar radiation was observed 12.76 MJ/MJ^2. The maximum solar radiation 14.90 MJ/MJ^2 was reportedin 2000 and in 1990, minimum solar radiation was 9.85/MJ^2. The overall coefficient of variability of solar radiation was 9.74 per cent and standard deviation was 1.24. The average production of rice was 1674.3 kg/ha in the last 35 years. The maximum rice production (2707.04 kg/ha) was observed in 2011 and minimum production (1596.18 kg/ha) in 1992. The overall coefficient of variability of rice production was 15.34 per cent with its 256.87 standard deviation.

b. Five Year Change

Researcher has attempts to study the climatic condition of 1979 to 2013 (35 years) and rice production. For this purpose, researcher has been considered rainfall, maximum temperature, minimum temperature, humidity and solar radiation parameters and how these parameters influencing on rice production with the help of correlation.

Table1.5: Climatic Condition and Rice Yield

Years	Productivity kg. /Ha	Rainfall mm	Mini. Temp. ^{0}C	Maxi. Temp. ^{0}C	Mean Temp. ^{0}C	Humidity (%)	Solar MJ/MJ^2
A	10.00	-351.51	-0.58	-0.17	-0.35	0.00	0.66
B	180.60	419.26	0.35	-0.16	0.10	1.20	-1.17
C	97.60	153.25	0.24	0.26	0.25	0.40	0.89
D	-14.80	-655.87	-0.09	0.54	0.23	-2.00	1.13
E	205.60	219.71	0.04	-0.09	-0.03	-0.40	-1.01
F	57.00	308.42	-0.09	-0.15	-0.12	2.80	-0.47
Coefficient of Correlation (R^2)		0.80	0.66	-0.46	0.15	0.26	-0.82

Source: Based on the Global Weather Data and Socio- Economic Abstract (1979-2013)

*(**Note**: Years: A 1979-83 to 1984-88, B 1984-88 to 1989-93, C 1989-93 to 1994-98*
D 1994-98 to 1999-03, E 1999-03 to 2004-08, F 2004-08 to 2009-13)

Rainfall

The correlation between rice production and monsoon rainfall showed that there is a high positive correlation between rice yield and rainfall during June to September (Tanaka, 1976). Extreme rainfall variability triggers environmental problems such as flood, gully erosion, drought and desertification, which have serious effect on the yield of rice (Ogbuene, 2010). The impact of five years average variations of rainfall on rice yield is shown in the Table No. 1.5 and fig 1.2. It is observed from the analysis that there are maximum positive increases in rice yield (205.60 kg/ha) during the year 1999-03 to 2004-08 (E), significant decrease has been observed in rice yield (-14.80 kg/ha) in the period 1994-98 to 1999-03 (D).

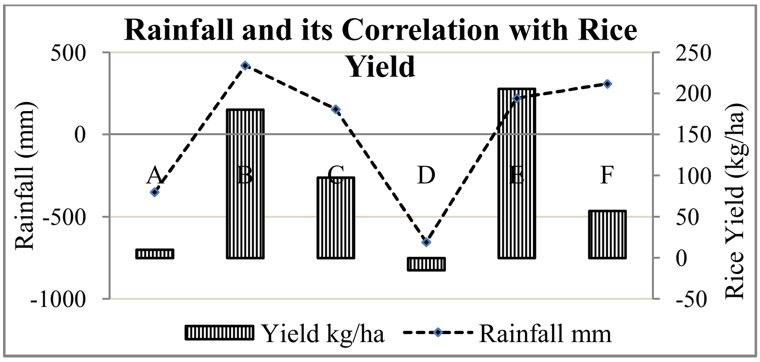

Figure 1.2

Figure 1.2 shows that the rainfall and its correlation with yield of rice. The production of rice was decreased during A and D period because rainfall was decreased by 3000 mm to 6000 mm than average. During the period B and E reported increase in rainfall by 2000 mm to 4000 mm and it is naturally support to increase in rice production nearly 170 to 200 Kg/he. This fact and figures indicate that rainfall is an essential climatic element for the growth and production of rice.

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Temperature

Rice plants are more sensitive with high temperature during critical stage i.e., seed development and flowering. High temperature makes better plant growth rate and could reduce growth duration leading to shorter grain filling period which varies from 25 days in the tropics to 35 days in the temperate zone (Swaminathan, 1984). The increase in daily maximum temperature averaged over flowering period above 36^0C, rice yield is decreases because of spikelet sterility induced by high temperatures. An increase in temperature will decrease the life span, grain yield, maximum leaf area index, biomass, and straw of the rice. This critical temperature differs according to variety, duration of critical temperature, diurnal changes and physiological changes of plant (Sridevi and Chellamuthu, 2015). The rice crop is adversely affected by high temperature in the lower elevation of the tropics and by lower temperature in the temperate regions.

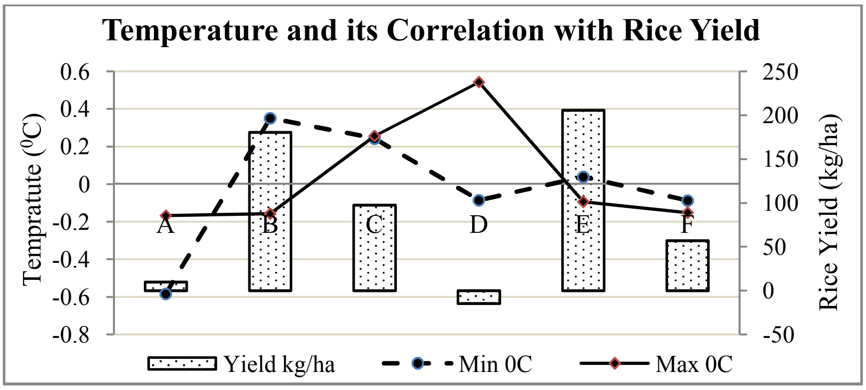

Figure 1.3

Due to the changes in maximum and minimum temperature yield of rice also changed and it is shown through the Table No. 1.5 and figure 1.3. The highest maximum temperature (0.54 ^{0}C) was observed during the period 1994-98 to 1999-03 (D) and it resulted to decreases rice yield (-14.80 kg/ha). The lowest maximum temperature (-0.09 ^{0}C) was observed during 1999-03 to 2004-08 **(**E) and it was fevered to increases rice yield (205.60 kg/ha). The highest minimum temperature (0.35 ^{0}C) was observed during 1984-88 to 1989-93 (B) and it helps to increases rice yield (180.60 kg/ha). The lowest minimum temperature (-0.04 ^{0}C) was observed during the period 1999-03 to 2004-08 **(**E) which was showed an increase in rice yield (205.60 kg/ha).It is observed that the temperature has deep correlation with yield of rice. Maximum and minimum temperature effects on the productivity of rice. It is observed that when maximum temperature increases by 0.3°C and minimum temperature decreases by -0.15°C from average temperature which result decrease in productivity of rice.

Relative Humidity

Optimum relative humidity for rice cultivation lies between 60 to 80 per cent (Nguyen, 2016). The Table No. 1.5 and fig.1.4 showed the changes in humidity and rice yield. Maximum decreases in humidity (-2 %) was observed during 1994-98 to 199-03 (D) and it decreased the rice yield (180.60 kg/ha). The maximum increase in relative humidity (2.80 %) was observed during 2004 -08 to 2009-13 (F) and it helps to increases rice yield (57 kg/ha).

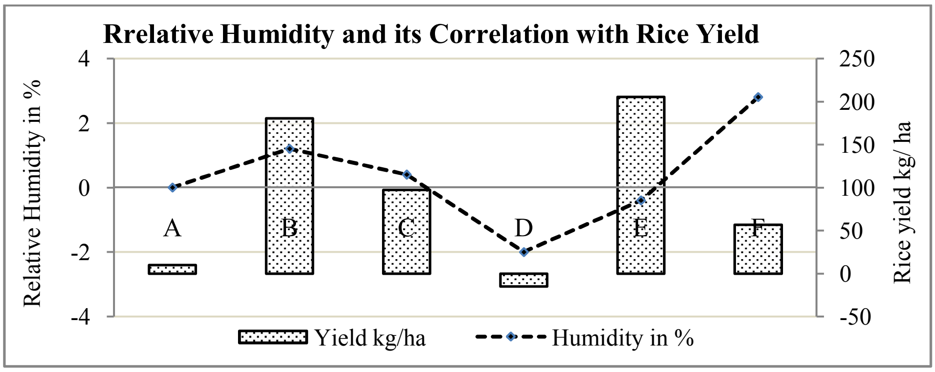

Figure 1.4

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It is clear from the figure 1.4, the amount of relative humidity was increased during the period A and F and it effect on productivity of rice which showed decrease in rice yield. In D period, relative humidity was remarkably coming down up to -0.2 per cent from average relative humidity and its result was seen in drop off rice yield. It was also observed during the period B, C and E, the relative humidity has depletion (1.0 to 0.2 %) from average relative humidity doesn't effect on productivity of rice but it fever to increase the productivity of rice. In the same period (B, C, and E) rice production reported 100 to 200 kg/ha. If fluctuation in humidity is increases then it affects rice crop significantly.

Solar Radiation

Solar radiation intercepted in rice canopy plays a major role in determining biomass and grain yield. The requirement of solar radiation is differed according to rice crop with the phytophases (Yoshida, 1981). The Table No. 1.5 and fig. 1.5 revealed the changes in solar radiation and rice yield. The highest decrease from average in solar radiation (-1.17 MJ/MJ^2) was observed during 1984-88 to 1989-93 (B) to decreases rice yield (-54.5 kg/ha). The maximum increase in solar radiation was 1.13MJ/MJ^2 observed during 1994-98 to 1999-03 (D) and due to this happen rice yield was decreased by -14.80 kg/ha. It was showed that if solar radiation increases from average by 0.5 MJ/MJ^2 to 1 MJ/MJ^2 then rice yield is decreased and when solar radiation was decreased by 1 MJ/MJ^2 then the yield of rice has increased by 150 Kg/hectare.

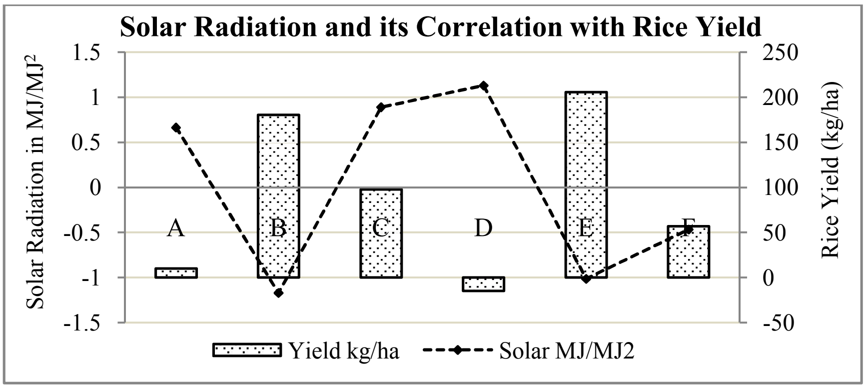

Figure 1.5

The coefficient of correlation of rice yield with climatic factors is depicted in the Table No. 1.5. The co-efficient of correlation of rainfall and rice yield was R^2 = 0.80, which is highly perfect positive correlation. The maximum temperature (-0.46) moderate negative correlation and minimum temperature (0.66) are moderate positive correlation. Relative humidity and rice have (0.26) insignificant correlation and solar radiation is (-0.82) highly negative correlation with rice crop.

X. Conclusion

The Rice is cultivated in Kharif season in the study area and hence rainfall plays dominant role particularly the growth and production of rice. The amount of rainfall and its variability highly affects the production of rice. It is observed that the productivity of rice is deeply concern with temperature. If temperature is increases from average maximum temperature, then average production of rice is also decreases. Relative humidity remains more than 70 per cent in monsoon but it doesn't affect this crop but when intensity of solar radiation increases then productivity of rice decreases.

Climate plays the major role in the growth and yield of rice on one side and on the other side weather elements (rainfall, temperature and solar radiation) are also influences on the growth, development and yield of rice. Relative humidity and wind velocity influence the crop growth to certain level. The direct effects of rainfall and temperature on rice development especially at flowering stage leading to spikelet sterility. Therefore, yield loss. The rainfall has shifted with an increasing trend during monsoon and almost stationary during other seasons. The rainfall variability has adverse effect on the yield of rice in the Pune division. The Rice cultivation continues to be a risky initiative, in spite of advances made in modern technologies in front of climatic changes.

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