Current Journal of Applied Science and Technology

35(3): 1-8, 2019; Article no.CJAST.47577
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Influence of Regional Weather Changes on Major Fruit Production and Productivity of Navsari District of Gujarat State, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author SS designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors PKS and NS managed the analyses of the study. Author NS managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2019/v35i330181
Editor(s):
(1) Dr. Diony Alves Reis, Federal University of the West of Bahia, Brazil.
Reviewers:
(1) Zakaria Fouad Fawzy Hassan, National Research Centre, Egypt.
(2) Shaymaa Ismail Shedeed, National Research Centre, Egypt.
(3) Engr. Olubanjo Olutola Obafemi, Federal University of Technology, Nigeria.
Complete Peer review History: http://www.sdiarticle3.com/review-history/47577

Original Research Article

Received 28 January 2019
Accepted 12 April 2019
Published 16 May 2019

ABSTRACT

Horticulture is a priority sector in many states of India as it has potential to improving the socio economic condition of the farmers. Gujarat state is the fourth leading state in fruit production with 9% share at the national level. This study is conducted to correlate major weather parameters with the production of major fruit crops of Navsari district in Southern Gujarat. The study reveals that production and productivity of 4 major fruits (banana, mango, sapota and papaya) has moderate negative correlation with mean annual temperature (MAT) i.e > -50% except the productivity of land under banana. Whereas, it showed very weak negative and non significant relation with total annual Rainfall (TAR). Correlation of all four fruit production ranged between -34 to -53% and -0.7 to -62% for productivity with both MAT and TAR, respectively.

Keywords: Ruit; weather; area; production; productivity; MAT; TAR.

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1. INTRODUCTION

Global food and nutritional security are threatened by weather and climate change which is one of the most important challenges in the 21st century to supply sufficient food for the increasing population while sustaining the already stressed environment [1,2]. Numerous studies have suggested that weather variability and climate change can have adverse impacts on global food production and food security [3,4,5,6]. The probability of extreme weather events will reduce food production [7,8]. The extreme weather events are expected to affect the volatility of crop yields and are seen as the principle immediate threat to global crop production system [9]. Several studies also indicated that rise in the intensity and frequency of extreme precipitation events will also reduce the crop yield [10,11,12,13,14,15,16,17,18,]. The changes in climatic parameters have been experienced globally since last few decades resulting in affecting the crop productivity and huge loses to the farming community. The rising temperatures and erratic rainfall patterns in many Agro climatic regions of India is affecting crop production thus threatening the food and water security of poor farming community of the country [19]. Situation is getting precarious as on one hand there is unchecked growth of population that has to be fed with limited resources and on the other hand there are huge losses due to floods, water scarcity and increasing temperature [20]. (Thus, there is a need to assess the impact of weather parameters on the productivity of fruit crops at the micro watershed level or district level. Gujarat state is the fifth largest producer of mango and accounts for 6% of the total production. Gujarat also stood second position in banana production in the country. Also, the state contributes major portion of sapota and papaya production [21]. The major fruit crops of South Gujarat are banana (*Musa sp*), mango (*Mangifera indica*), sapota (*Manilkara zapota*) and papaya (*Carica papaya*), further, these fruit crops are most widely cultivated in the tropics and the subtropics for its economic and nutritional values. This paper is an attempt to analyse the influence of weather on crop productivity with special reference to Navsari District of South Gujarat.

2. MATERIALS AND METHODS

Navsari district is situated in western coast and is in southern Gujarat. It is situated between 20°1' & 24°7' North Latitude and 68°4' to 74°4' East Longitude covering geographical area of 196 024 km^2, which is six percent of the country [21]. The total geographical areas of Navsari district is 2657.56 Km^2 [22]. The state has tropical and sub-tropical climate and the weather in Navsari is sunny from September to May, and rainy from June to August. The average maximum and minimum temperatures are 40°C and 18°C, respectively and the mean temperature varies around 29°C. The average annual rainfall of the district is around 1600 mm and according to climate classification of Koppen-Geiger the location falls under tropical wet and dry climate is a type of climate that corresponds to the categories "Aw" and "As". The climate of Navsari is suitable for production of fruits like; banana, mango, sapota and papaya. Fruit production plays a crucial role in improving the economic condition of farmers of Navsari.

The present study is conducted on the basis of secondary data, from 2007 to 2017 (Daily climatic data converted in to annual data), on area, production and productivity of four major fruits in Navsari district that was collected from the Director of Horticulture, Agriculture Farmers welfare and Co-operation Department, Government of Gujarat [23]. The data on weather parameters viz. average annual rainfall, minimum and maximum temperature was obtained from Department of Meteorology, Navsari Agricultural University, Gujarat. The compound growth rate of area, production and productivity of fruit crops were worked out using the exponential function of the form [24] and tested for significance by student t test at $p < 0.05$ and 0.01 [25].

$$Y = A\,B^{X}$$

By taking logarithm of both sides, the equation takes the form:

$$\text{Log } Y = \text{Log } A + X \text{ Lob } B$$

Y= Dependent variable (Area, Production and Productivity)
X= Independent variable (Time or Years)
A= Constant
B= Regression coefficient

$$\text{Compound growth rate (r)} = (B-1)*100$$

To measure the instability in area, production and productivity, coefficient of variation was used as measure of variability [26]. The coefficient of variation (C.V.) was calculated by the formula:

$$\text{Coefficient of Variation (\%)} = \text{Standard deviation/ Mean X } 100$$

The correlation between weather parameters, production and productivity was also calculated using the Karl Pearson's correlation coefficient i.e.

$$r = \frac{\sum XY - \frac{\sum X \sum Y}{n}}{\sqrt{\left(\sum X^2 - \frac{(\sum X)^2}{n}\right)\left(\sum Y^2 - \frac{(\sum Y)^2}{n}\right)}}$$

where,

r = Correlation coefficient
X and Y = weather parameters, production and productivity
n = Number of observations or time in number of years

The weather parameters were correlated with all the dependent variables using the statistical method given by Panse and Sukhatme [25].

3. RESULTS

3.1 Growth and Instability in Area, Production and Productivity of 4 Major Fruits in Navsari

Trend of data on area, production and productivity of Banana, Mango, Sapota and Papaya is depicted in Figs. 1-5. The compound growth rates and Coefficient of Variation of area, production and productivity of Banana, Mango, Sapota and Papaya in Navsari district of Gujarat for 11 years overall worked out and presented in Table 1. The study reveals that, among the four major fruits, as per Pearson's correlation test, papaya shows the significant and highest growth rate for area (11.68% per annum), production (15.06% per annum) and productivity (2.10% per annum) which was followed by Banana for area and production and Sapota for the productivity during the study period. In fact, productivity of land under banana has decreased by -0.33% per annum.

Studying only growth rates is not worth without measuring the variability because the growth rates explain only the rate of growth over the period while, variability *i.e.,* coefficient of variation judges the real fluctuation in growth performance. Highest degree of instability *i.e.,* more than 70% observed for the area and production of Banana, which was followed by papaya *i.e.* 63.40% for area and 70.20% for production. Productivity of land under the all fruit crops showing more stable growth 24.01% for mango, 17.19% for sapota, 15.86% for papaya and 5.35% for banana.

3.2 Weather Pattern (Mean Annual Temperature and Rainfall) of the Region for the Studied Period

Table 2 depicts the weather parameter data *i.e* Minimum temperature, Maximum Temperature, Mean Annual Temperature (MAT) and Total Annual Rainfall (TAR) (mm) for the Navsari District. Fig. 5 depicted the pattern of MAT and TAR from 2007 to 2017 for Navsari district. MAT was higher during the 2009 and 2011 which was more than 28°C, whereas for the other studied year it was between 26°C to 27°C. In case of TAR, higher rainfall observed during 2013 which was more than 2442.6 mm. Decreasing trend of rainfall observed from 2007 to 2017. During the year 2012 and 2015 onward rainfall was less than the district average.

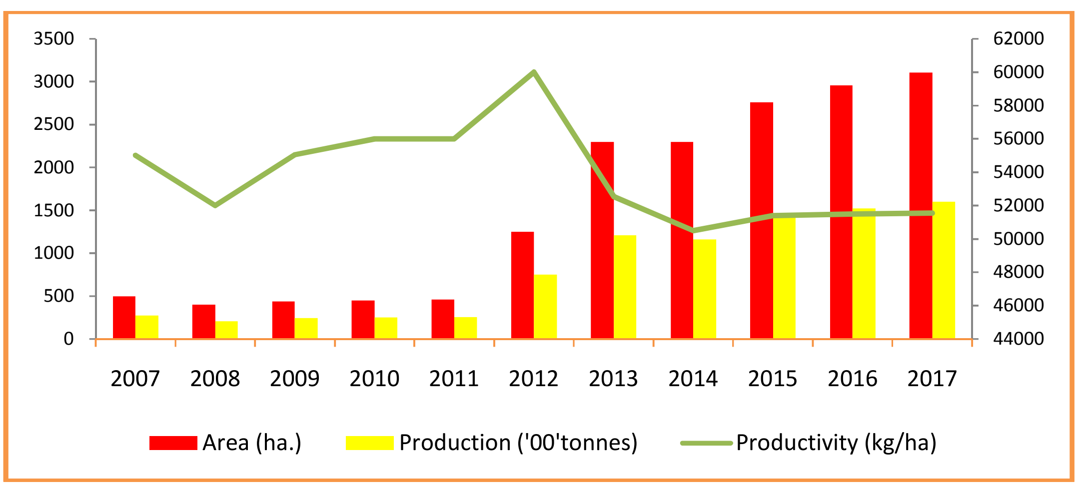

Fig. 1. Trend in area, production and productivity of banana

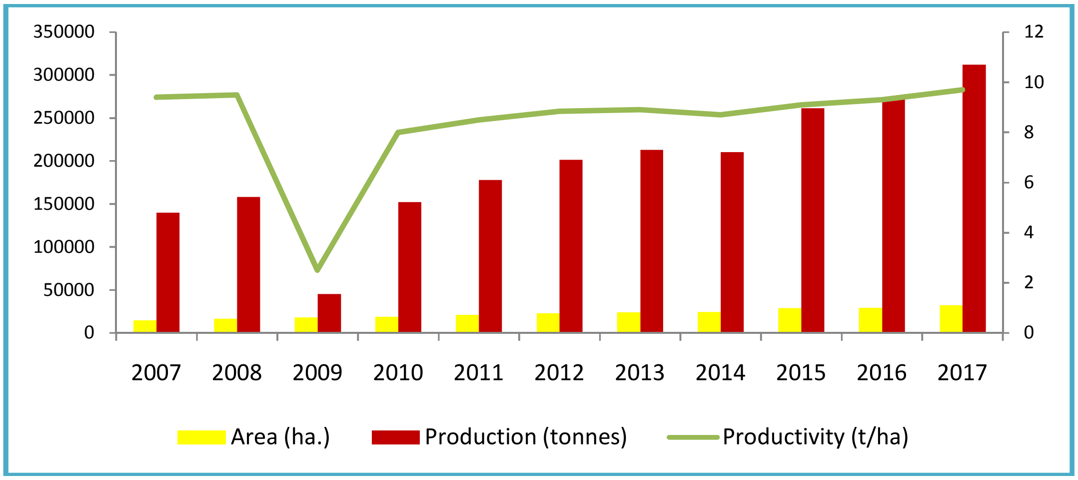

Fig. 2. Trend in area, production and productivity of mango

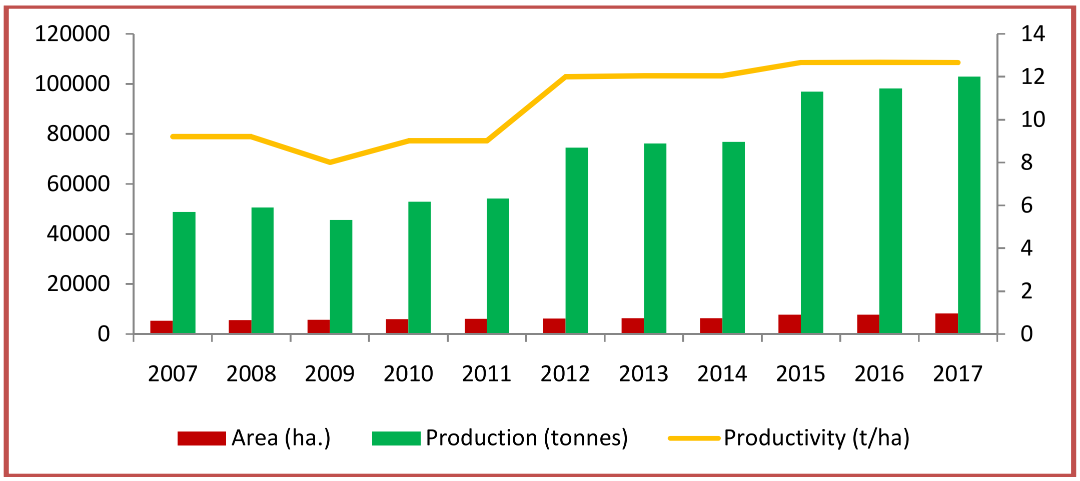

Fig. 3. Trend in area, production and productivity of sapota

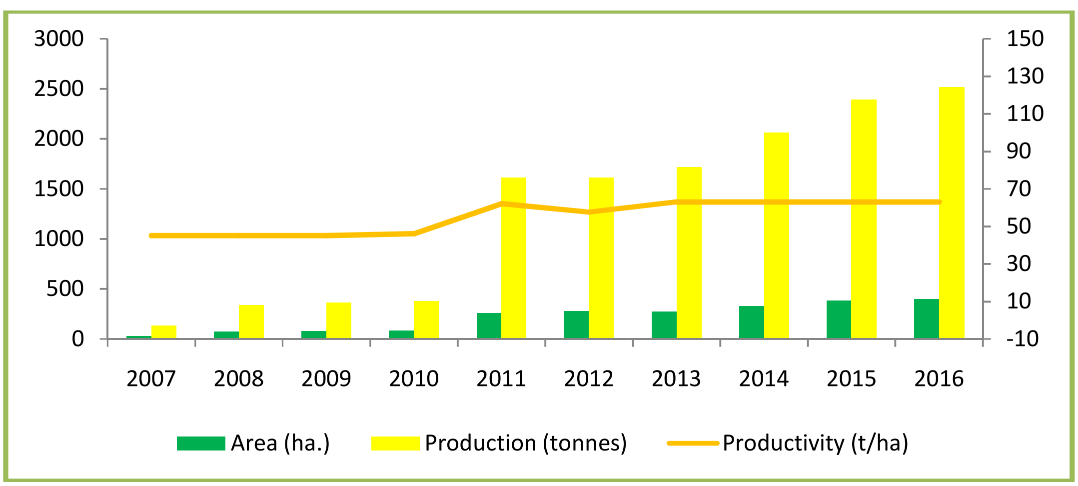

Fig. 4. Trend in area, production and productivity of papaya

Table 1. Compound annual growth rate (CAGR) and coefficient of variation for banana, mango, sapota and papaya

Crop	Area		Production		Productivity	
	CAGR (% P.A.)	Coefficient of variation (%)	CAGR (%P.A.)	Coefficient of variation (%)	CAGR (%P.A.)	Coefficient of variation (%)
Banana	11.47**	74.51	11.11**	71.87	-0.33 NS	5.35
Mango	3.25**	24.34	4.96*	37.54	1.65NS	24.01
Sapota	1.83**	15	3.91**	30.56	2.04**	17.19
Papaya	12.68**	63.40	15.06**	70.20	2.10**	15.86

*** Significance at 1 percent level and * significance at 5 percent level (student t test at p < 0.01 and 0.05 [25]*

3.3 Correlation between Rainfall, Temperature, Production and Productivity of Major Fruit Crops

Table 3 representing correlation between climatic parameters such as MAT and TAR with the production and productivity of four major fruits in Navsari district. Productivity of Banana weakly but positively correlated (33%) with the MAT but the production was moderately negative (-50 %) with the MAT. In case of TAR, both the production and productivity of banana negatively correlated which was about -0.37 % and -3.9%, respectively.

Table 2. Annual weather parameter record of Navsari district from 2007-2017

	Maximum temp. (°C)	Minimum temp. (°C)	Mean annual temperature (°C)	Total annual rainfall (mm)
2007	32.3	21.4	26.8	1696.8
2008	31.8	21.1	26.4	2030.0
2009	33.2	22.9	28.0	1582.0
2010	31.6	21.7	26.6	2180.4
2011	34.4	22.3	28.3	1597.5
2012	32.3	20.7	26.5	1262.0
2013	31.9	21.1	26.4	2442.6
2014	32.2	21.1	26.6	1539.0
2015	32.1	20.9	26.5	1219.5
2016	32.2	20.5	26.3	1411.0
2017	32.8	20.7	26.7	1358.0

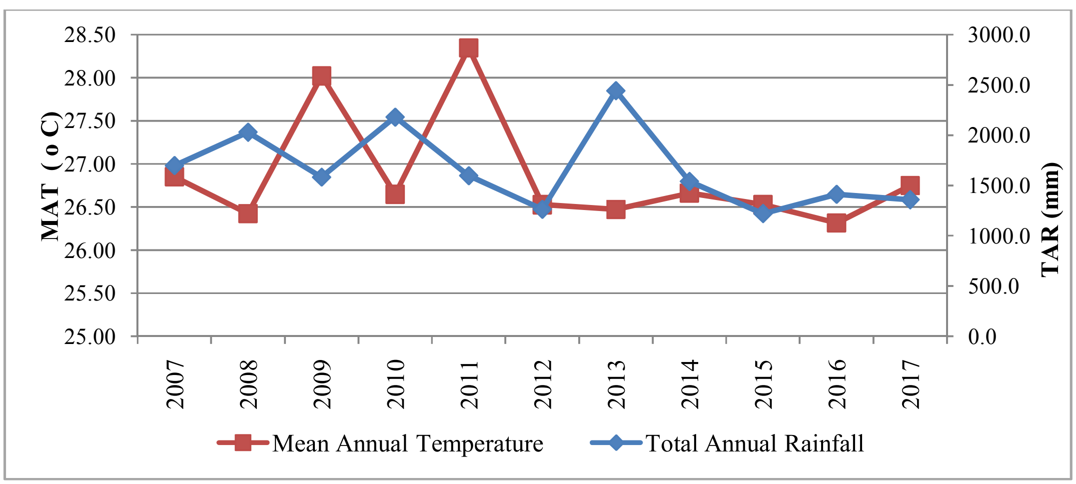

Fig. 5. Pattern of mean annual temperature and total annual rainfall from 2007 to 2017

Table 3. Correlation of production, productivity with mean annual temperature and total annual rainfall for major fruits of the Navsari

	Mean annual temperature		Total annual rainfall	
	Production	**Productivity**	**Production**	**Productivity**
Banana	-0.50 (-50%)	0.33 (33%)	-0.37 (-37%)	-0.039 (-3.9%)
Mango	-0.53 (-53%)	-0.61 (-61%) *	-0.34 (-34%)	-0.007 (-0.7%)
Sapota	-0.50 (-50%)	-0.62 (-62%) *	-0.48 (-48%)	-0.37(-37%)
Papaya	-0.52 (-52%)	-0.56 (-56%)	-0.49 (-49%)	-0.53(-53%)

*Pearson correlation *Significance at 5 percent level*

Production and productivity of remaining fruits *i.e.* mango, sapota and papaya showing negative correlation with MAT and TAR. Production and productivity of mango also negatively correlated with MAT (-53% production and -61% productivity) and with TAR (-34% and -0.7% respectively for production and productivity). Sapota also shows more or less similar correlation as of mango *i.e* about -50% for production and - 62% productivity for MAT, whereas it was about -48% for production and - 37% for productivity with TAR. The correlation between production of papaya with MAT and TAR was also negative i.e. 52% and -49%. The strength of correlation of productivity of papaya with MAT and TAR was also negative *i.e.* about - 56% and -53%. In the correlation study only significant associations (P value < 0.05) were productivity of mango (-61 %) and sapota (-62%) with MAT.

4. DISCUSSION

According to results, production of fruit and productivity of land is negatively correlated with the temperature and rainfall, trend of correlation results are supported by the previous findings of [27,28]. Production of the fruits and productivity of land has weak negatively correlation with the temperature this is partly because some of the negative impacts of temperature change of factors like soil erosion, nutrient cycling and crop protection. Climatic warming advances both the date of the last spring frosts and the dates of flowering, and the risk of damage to flower buds caused this leads to low fruit production [29]. An increase in rainfall, mainly due to higher temperature and pressure and more atmospheric moisture, may result in high intensity precipitation events, causing increased soil erosion [30], it directly affects on the productivity of land and fruit production. High rainfall associated with the flooding and the spill-over effects might also be responsible for the low fruit production and lowering productivity, this reflects negative correlation of TAR with production of fruit and productivity of land. Only the productivity of banana has weak positive correlation with temperature is exceptional result among different fruits studied.

5. CONCLUSION

From above study it can be concluded that the area and production of banana, mango, sapota and papaya have been increased over the period, whereas productivity decreases over the study period. When the production and productivity of major fruit correlate with the major weather parameter like Mean Annual Temperature and Total Annual Rainfall, the association is ranged between moderately negative to weakly positive trend. In the given correlation study, overall can be stated that only the effect MAT on the productivity of land cultivated under mango and sapota is notable. Otherwise all factors have very weak and negative association. Hence, the study reveals that there is very less impact of weather changes on production and productivity of major fruits of Navsari District. To establish food security, to estimate regional fruit production in future, and to examine the impacts of weather and climate change on fruit production and productivity this study must be conducted on a large scale and might be need to take other climatic factors in consideration.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/47577