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Research Article

STUDY OF NON-PARAMETRIC TRENDS OF AREA, PRODUCTION AND PRODUCTIVITY OF MAIZE IN INDIA

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Abstract: The investigation was carried out for 20 year's time series data of area, production and productivity of maize used for the trend analysis using non parametric test, data collected from the ICAR-IASRI databook 2018. The average area under maize cultivation during study period was found to be 7.83 (Million Ha) with standard deviation of 1.10 with a production of 17.36 (Million ton). Mann Kendall test reveals that total area and production was found to increasing over a period of time with a significant p - values.

Keywords: *Mann-Kendall Test, Co-efficient of Variation*

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Introduction

Maize (*Zea mays* L.) is one of the most adaptable emerging crop shavings in a wider range of agro-climatic situations. In the world, maize is known as the queen of cereals because it has the highest grain yield capability among cereals. It is grown at almost 150 m ha in approximately 160 countries with a wider range of soil, environment, ecology and management practices, which contributes 36% (782 m t) of global grain production. The states of Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan and Punjab account for over 75 percent of the area and production of this cereal in the country

In India, maize is the third-largest cultivable food crop after rice and wheat. It is estimated to be cultivated in 8.7 mha (2010-11) during the most of the Kharif season, which covers 80 percent of the region. Maize in India leads at most 9 percent to the national food basket and apart from creating jobs, to more than 100 million people in the agricultural and backward industrial and agricultural sectors in India.

Maize is well adapted to a broad range of climatic conditions and is grown in both tropical and temperate regions, from sea-levels to 2,500 m altitudes. However, it is vulnerable to frost at all phases of crop growth. Maize can be effectively grown in a wide range of soils ranging from loamy sand to clay loam. Nonetheless, soils with a good organic matter content with a high-water retaining capacity with balanced pH are regarded as good for increased productivity [1-13].

Material and Methods

In the current study, area production and productivity of jowar in India, collected from the official website of ICAR-IASRI which is in public domain. For statistical study data collected from 1997 to 2016 is used for the analysis with an objective of knowing the trend in datasets.

Mann-Kendall test: To analyse temporal variation *i.e.* variation of rainfall across different period in 16 rain gauge stations of the district can be analysed by trend. Mann-Kendall test a non-parametric statistical procedure is used in analysing trends in data over time. Mann-Kendall Statistic measures the trend in the data. Positive values indicate an increase in constituent concentrations over time, whereas negative values indicate a decrease in constituent concentrations over time.

The intensity of the trend is directly proportionate to the magnitude of the Mann-Kendall statistic (*i.e.* the large magnitude indicates a strong trend).

$$sign(X_j - X_k) = \begin{bmatrix} 1 & if\ x_j - x_k > 0 \\ 0 & if\ x_j - x_k = 0 \\ -1 & if\ x_j - x_k < 0 \end{bmatrix}$$

Mann-Kendall Statistic (S) is described as the total of the number of positive differences minus the number of negative differences defined below.

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sign(x_j - x_k)$$

Where j = 1,2,3,..., n-1 and k = j+1, j+2, j+3, ...n.

Where x_j and x_k are the annual values in years j and k, j > k, respectively

For large Sample s

Case 1 (no ties): for large sample (about n>8) S is normally distributed with

$$E(s) = 0\ VAR\ (S) = \frac{n(n-1)(2n+5)}{18}$$

Case 2 (tied observations) in case of ties the variance of S is

$$VAR\ (S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{g} t_p(t_p-1)(2t_p+5)\right]$$

Where, n is the number of data points

g is the number of tied groups

t_p is the number of data points in the p^{th} group

$$Z = \begin{cases} S > 0 & \frac{(s-1)}{\sqrt{VAR(s)}} \\ S = 0 & s = 0 \\ S < 0 & \frac{(s+1)}{\sqrt{VAR(s)}} \end{cases}$$

If Z is negative and p < 0.05-trend is said to be decreasing. If Z is positive and p < 0.05-trend is said to be increasing. If computed probability p > 0.05, then there is no trend.

Table-1 *Mann Kendall statistics values*

Measures	Mann Kendall test statistics		
	Area	Production	Productivity
Z - test	5.80	5.45	4.70
S	180	169	146
Var(S)	950.00	949.00	950.00
p - value	6.34E-09	4.94E-08	2.55E-06
n (count)	20.00	20.00	20.00

Table-2 *Descriptive Statistics*

Measures	Descriptive Statistics of Jowar		
	Area	Production	Productivity
Minimum	6.20	10.82	1681
Maximum	9.86	26.26	2676
Mean	7.83	17.36	2174.75
Variance	1.20	26.29	129140.62
SD	1.10	5.13	359.36

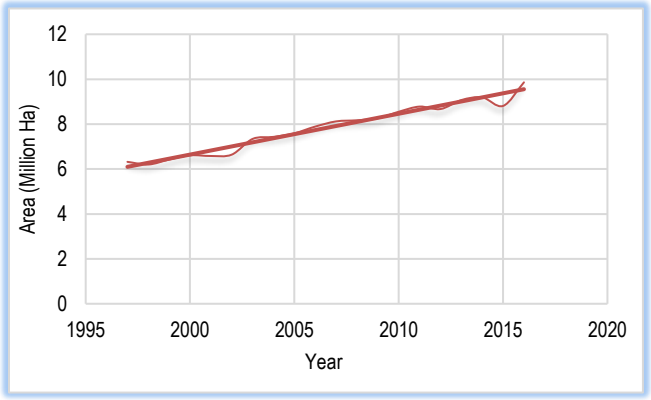

Fig-1 Time series plot of total area under Maize cultivation

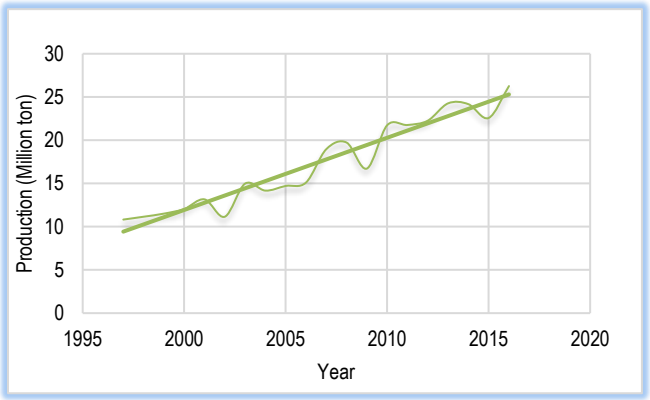

Fig-2 Time series plot of total production of Maize in India

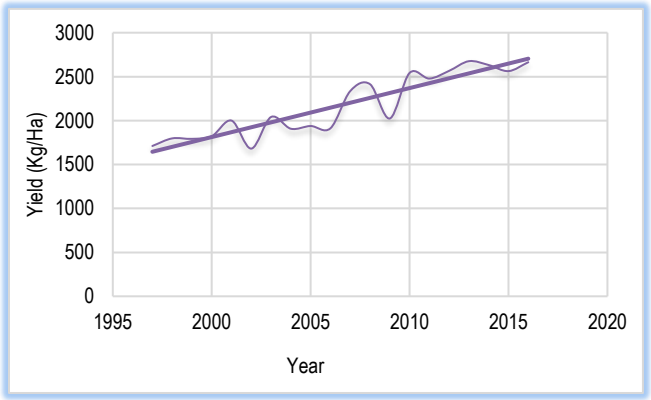

Fig-3 Time series plot of productivity of Maize in India

To analyse spatial variation *i.e.*, variation of rainfall across space for different raingauge stations, coefficient of variation for different periods is used and this is defined as the ratio of standard deviation to the mean. It is expressed in percentage.

Conclusion

The descriptive statistics of time series data (1997-2016) of maize area, production and productivity found to be with a minimum value for area is 6.2 (Million Ha) during the year 2016 and maximum area is 9.86 (Million Ha) during the year 1997. Over a period of time total area under maize cultivation found to increasing which is graphically presented in the [Fig-1]. The average area under the jowar cultivation during the study period is 7.83 (Million Ha). The average productivity of maize during study period is 2174.75 Kg/Ha. Due to continuous increase in cultivable area under maize results in increase of production which is visualized in the [Fig-2], [Fig-3] and [Table-1]. From the [Table-2] Mann kendall test reveals that for area and production of maize in India found to be increasing and is statistically significant from p-value. In case of productivity of trend found to be increasing trend which may be due to use of improved technical agriculture operation and use of high yielding varieties and is statistically significant from p-value.

Application of research: Time series analysis helps in forecasting the market price for farmers in order to take better decision to augment the profitability.

Research Category: Time series analysis

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Study area / Sample Collection: Department of Agricultural Statistics, University of Agriculture Science, Bengaluru, 560065, India and ICAR-IASRI databook 2018

Cultivar / Variety / Breed name: Maize (*Zea mays* L.)

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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