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Research Article

Trend Analysis of Area, Production and Yield of Major Crops of Assam

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ABSTRACT

This paper emphasized trend analysis, growth rate and instability of the area, rice production and yield, and jute Rapeseed & Mustard in Assam. In this study, the different linear and non-linear function was used to fit the best-fitted Trend with the help of the value of measures of determination (R^2) and mean square error (MSE). Quadratic functions were found to be the best-fitted trend equation for the estimation of area, production and yield of selected crops of Assam. The result shows an increasing trend for area, production and yield, except the area of Jute shows decreasing Trend. The compound growth rate of area, production and yield of Rice, Jute Rapeseed & Mustard seems significant and positive growth, but the area and production of Jute revealed a negative growth rate in Assam. From the value of the coefficient of variation (C.V), it has been observed that the production of all three crops has higher variation and the area of all selected crops has lower variation. The yield of Rice seems to have a very high variation in Rice, but Jute Rapeseed & Mustard shows a stable result.

Keywords: *Agricultural crop, Compound growth rate, Growth instability, Trend.*

INTRODUCTION

Meeting the food demand of the over populated country like India is a major challenge. According to the Food and Agriculture Organisation (FAO), food production in the world needs to grow by over 40% by 2030 and 70% by 2050 (FAO, 2009). Many researchers are trying to find a smooth way to serve the increasing population. To fulfil the requirements of additional food demand in our country, we must concentrate on increasing the production of crops. Different researchers have suggested some meaningful and scientific ways by their regional investigations regarding different agricultural crops' analysis. These meaningful suggestions can help the policy planners to make sustainable development of the entire society.

Like the other parts of the country, Assam is also an agriculturally based state.

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The economy and the livelihood of Assam are mainly based on agriculture and this sector provides more than 50% employment of the rural population. Almost all the neighbouring hill north east states depend on Assam for agricultural products. But in spite of its importance, the progress of agricultural product is far from satisfactory. It has a significant impact on the state economy as well as the national economy. As a result, the state economy depends on the development of agricultural production.

There are many agricultural productions which enhance the food strength of the individual as well as boost the economic condition of the state-Assam. The state of Assam produces both food and cash crops. Different varieties of Rice, wheat, maize, and pulses are principal food crops and tea, Jute, sugarcane, oilseeds, tobacco, and cotton are the major cash crops which are produced in Assam. Rapid changes of soil type, nature of the topography, demand of food etc. are not balanced everywhere. So, an analysis or investigation of the area, production and yield of agricultural crops in the past and growth rate can take a step for future trend line of agricultural crop. To make an effort to accomplish a study on-trend and the growth rate of area, production and yield of major food and cash crops in Assam. This paper has confined itself within the study of area, production and yield of three important crops in Assam, Viz., rice (the most important traditional food crop), Jute (declining but important fibre cash crops) and Rapeseed & Mustard (major oilseed crop). Rice and Jute are the main economic crops in Assam. These three select crops have great significance in the state agriculture.

MATERIALS AND METHODS

To conduct this work, yearly data of major food crops (Rice) and cash crops (Jute and Rapeseed & Mustard) were collected from various publications and issues of Directorate of Economics and Statistics, Govt. of Assam in the time span 1951-2018.

2.1. Trend analysis of the Area, Production, and Yield:

To assess the Trend of area, production, and productivity of selected agricultural crops in Assam, the following three functional forms have been selected

Linear function: $Y = a + bt$

Quadratic function: $Y = a + bt + ct^2$

Exponential function: $Y = ab^t$

Where, Y (area, production, and yield) is the dependent variable.

t (time) is the independent variable.

The selection of the best trend equation from the above function is very important. The functional form having the highest coefficient of determination (R^2) and lowest Mean Square Error (MSE) has been selected for fitting the Trend of selected crop. The formula for coefficient of determination (R^2) had been computed as:

$$R^2 = 1 - \frac{\sum(Y-\hat{Y})^2}{\sum(Y-\overline{Y})^2}$$

Where,

Y = Original value

$\hat{Y}$ = Estimated value

$\overline{Y}$ = Mean value

The Mean Square Error had been calculated as,

$$MSE = \frac{\sum (Y_i-\hat{Y})^2}{n}$$

Where,

Y_i = Original value

$\hat{Y}$ = Estimated value

Where R^2 is used to explain the variability of the dependent variable predictable from the independent variable. For the selected functions, trend values have been computed and curves have been drawn for observed and Trend values.

2.2. Compound Growth Rate of Area, Production, and Yield

The Compound Growth Rate (C.G.R) of area, production and yield of autumn rice (February-June), winter rice (June-September), Summer rice (November- May), total Rice, Jute (April-August) and Rapeseed & Mustard (October-March) have been evaluated in the state of

Assam during the period from 1951-52 to 2018-19.

The Compound Growth Rate (C.G.R) has been evaluated by using the exponential function of the form.

$$\mathbf{Y = ab^t}$$

Where Y is the variable under study (area/ production/yield); a and b are the parameters to be estimated through the method of least squares, and t is the independent time variable measured in a unit length of the year.

By transforming the above equation into the log-linear form,

Log Y = log a+ t (log b) or

Y = A + Bt

Now, the Compound Growth Rate percent (C.G.R %),

C.G.R%= (b-1) × 100

Where,

b = Antilog of B

To study the instability of different types of Rice, Jute and Rapeseed & Mustard the Coefficient of Variation (C.V %) has been computed by using the following formula,

C.V % = (Standard Deviation / Mean) × 100

RESULTS AND DISCUSSION

Trend Analysis:

The coefficient of determination (R^2) and Mean Square Error (MSE) have been calculated for selecting the best functional form. The function with the highest value of R^2 and the least value of MSE has been selected as the best-fitted model.

The values of R^2 and MSE have been presented in Table 3.1. The trend curves were also fitted separately for the area, production, and yield of different types of Rice in the State of Assam for getting better information for the research study.

Table3.1. Coefficient of determination (R^2) and MSE values for different functions in Assam for the study period 1951-1952 to 2018-19

Crop	Variable	Linear function		Quadratic function		Exponential function	
		R^2	MSE	R^2	MSE	R^2	MSE
Rice	Area	0.8101	13623600000	**0.9450**	**14324100000**	0.7633	21024000000
	Production	0.8952	14574000000	**0.9479**	**29076300000**	0.9447	69811500000
	Yield	0.3799	300948.6435	**0.5109**	**237356.9074**	0.4309	290562.4721
Jute	Area	0.7932	133786513.8	**0.8105**	**122597077.1**	0.7555	158639390.4
	Production	0.0809	64169724438	**0.1110**	**62065872482**	0.0764	65094564533
	Yield	0.6386	27951.43234	**0.6724**	**25336.75717**	0.6546	26793.1885
Rapeseed & Mustard	Area	0.6723	1827270181	**0.7505**	1391238176	0.5914	2394908068
	Production	0.7813	511639784.4	**0.7839**	505604785.6	0.7310	661062680.3
	Yield	0.5910	2663.002222	**0.6735**	2125.838392	0.6145	2518.96658

As per the values shown in bold for R^2 and MSE obtained from Table 3.1, the quadratic function has been found with the highest value of R^2 and least value of MSE for all crops viz., Rice, Jute and Rapeseed & Mustard in the state of Assam. Hence, the quadratic equation has been selected as the best-fitted trend equation for the estimation of area, production, and yield of Rice, Jute and Rapeseed & Mustard in the state of Assam.

The results of Rice, Jute and Rapeseed & Mustard for the state Assam for the study period (1951-1952 to 2018-19**)** have been presented in Table 3.2 to 3.4.

The trend lines for area, production and yield of Rice, Jute and Rapeseed & Mustard for the

state Assam have been presented in figures from figure 3.1 to figure 3.9.

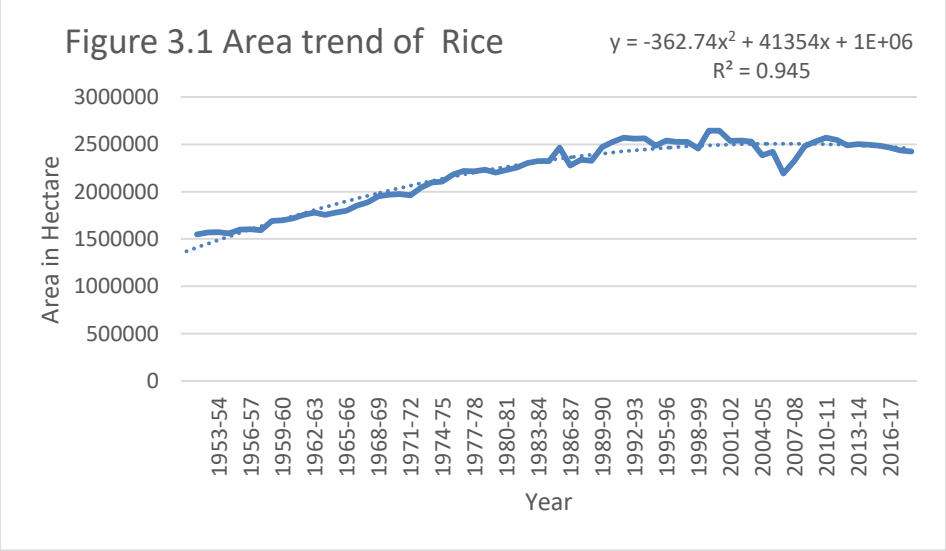
The results of Rice for Assam for the study period (1951-1952 to 2018-19**)** have been presented in Table 3.2.

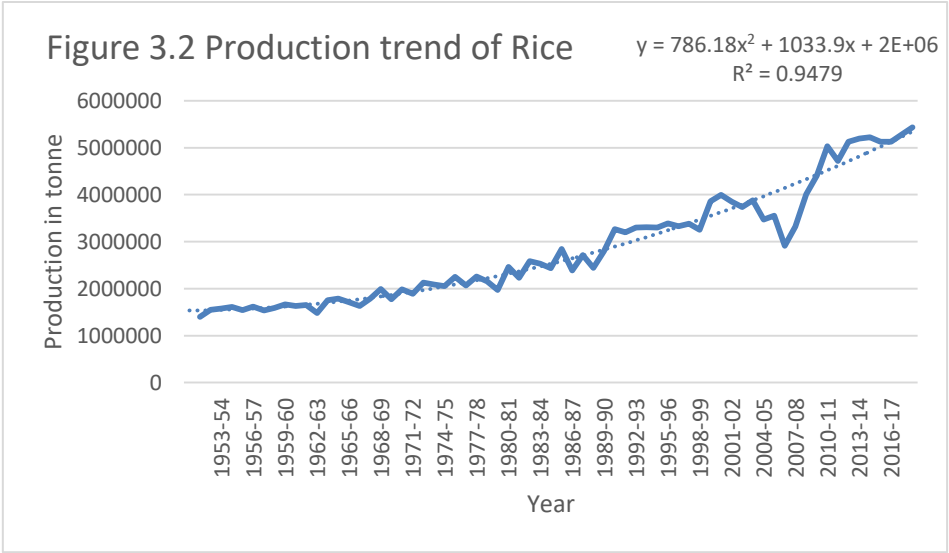
Table 3.2 Fitted trend equations of Rice

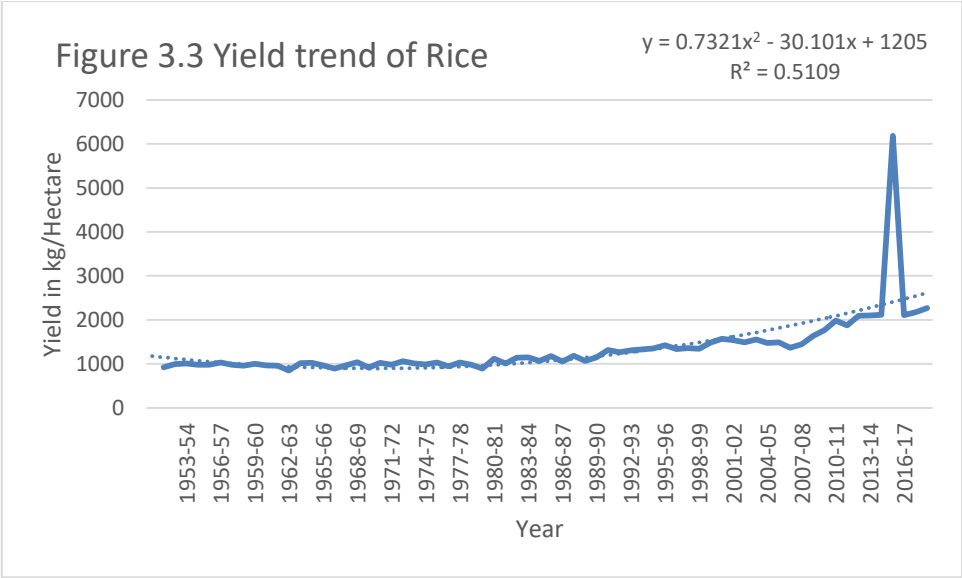
Crop	Variables	Fitted trend equation
Rice	Area	$y = -362.74x^2 + 40629x + 1E+06$
	Production	$y = 786.18x^2 + 2606.3x + 2E+06$
	Yield	$y = 0.7321x^2 - 28.637x + 1175.6$

From Table 3.2, the value of coefficient 'c' of the quadratic equations of area of Rice in the state Assam has been found to be negative which represents a decreasing trend of an area in the latter part of the study. The value of 'c' in the quadratic function for production and yield has been found to be positive that represents an increasing trend in the later part of the study period. The 'b' value in the fitted trend function for area and production has been estimated as 40629, 2606.3 respectively. This showed an increasing trend in the first half of the study period. The value of 'b' has been found to be -28.637 for yield showed a negative trend in the former part of the study.

The trend lines for respective trend equations have been presented in the figures from 3.1 to 3.3.







The trend curve of area, production, and yield has been provided in Figure 3.1, 3.2, and 3.3. The trend line of area, production and yield of Rice has been found with an increasing trend. The rate of increase of Trend of the yield of Rice is lower than the Trend of the area and production of Rice. Hence the production of Rice is influenced by the area of Rice than the yield.

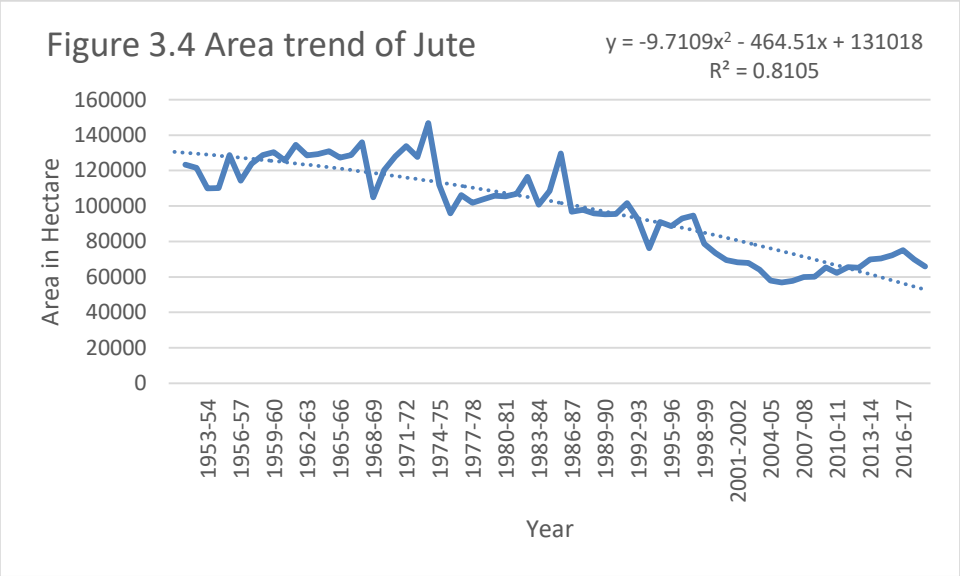
The results of Jute for Assam for the study period (1951-1952 to 2018-19**)** have been presented in Table 3.3.

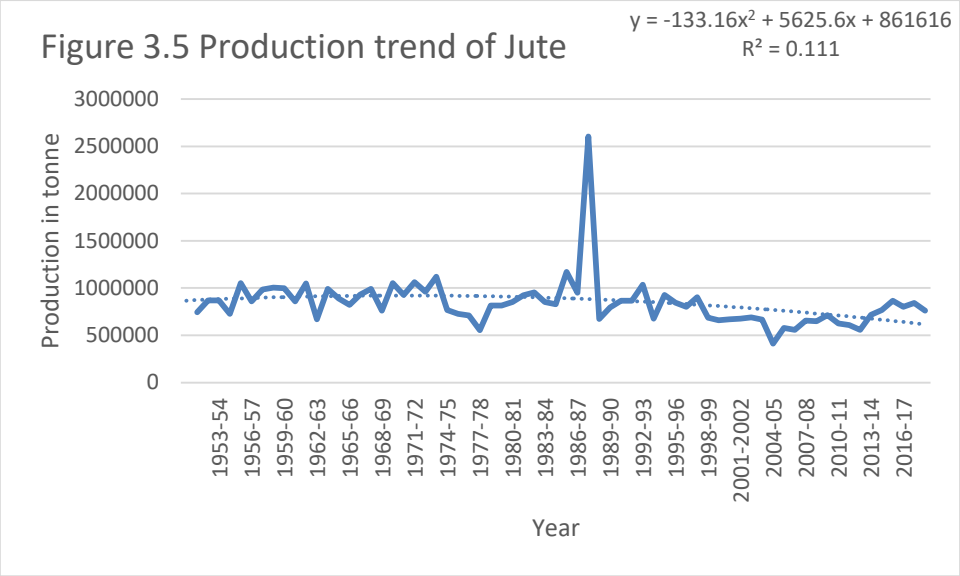
Table 3.3 Fitted trend equations of Jute

Crop	Variables	Fitted trend equation
Jute	Area	$y = -9.7109x^2 – 464.51x + 131018$
	Production	$y = -133.16x^2 + 5625.6x + 861616$
	Yield	$y = 0.1484x^2 + .7824x + 1270.4$

It has been observed from Table 3.3, the value of coefficient 'c' in the quadratic equation for Jute in Assam have been found to be positive only for yield. From these values of 'c', it has been observed that yield showing an increasing trend in the later part of the study. But in the case of area and production, the 'c' value observed was -9.7109 and -133.16 which following a declining trend in the later part of the study. According to the values of 'b', the production and yield have been found with an increasing trend in the first part of the study but the area following a decreasing trend.

The trend lines for respective trend equations have been presented in the figures from 3.4 to 3.6.





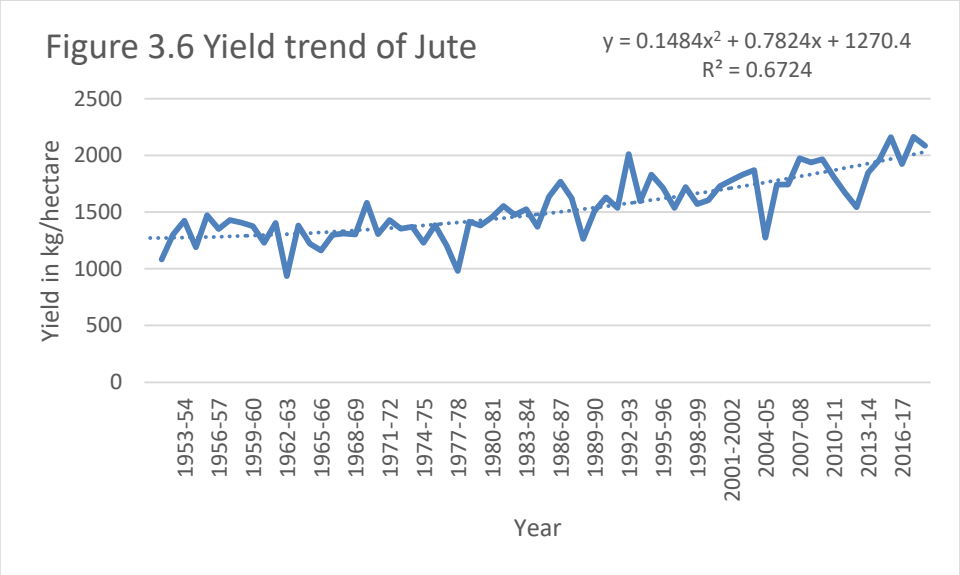


Figure 3.4, 3.5, and 3.6 show the trend curve of area, production, and yield of Jute in the state of Assam. From there, it has been observed that area following a decreasing trend and yield following an increasing trend and in production the trend line is slowly decreasing. Moreover, the slope of the area has been observed to be more than the slope of yield. Hence a decreasing trend in the area contributed more to the decreasing Trend of the production of Jute in the state Assam.

The results of Rapeseed & Mustard for Assam for the study period (1951-1952 to 2018-19**)** have been presented in Table 3.4.

Table 3.4 Fitted trend equations of Rapeseed & Mustard

Crop	Variables	Fitted trend equation
Rapeseed & Mustard	Area	$y = -60.62x^2 + 7423.4x + 49654$
	Production	$y = -7.1317x^2 + 2684.5x + 22867$
	Yield	$Y = 0.0673x^2 - 1.4821x + 425.2$

As per Table 3.4, the value of coefficient 'c' in the quadratic equation for Rapeseed & Mustard in Assam has been found to be negative for the area and production. The values of 'c' for the area and production have been estimated as -60.62 & -7.1317 respectively. From these values, it has been observed that area and production were showing a decreasing trend in the later part of the study. The value of c was found to be positive for yield which is estimated as .0673. that means there is an increasing trend in the later part of the study. According to the value of 'b', the yield (- 1.4821) has been found with a declining trend in the first part of the study. But for production and yield (7423.4, 2684.5 respectively) it follows an increasing trend in the first part of the study.

The trend lines for respective trend equations have been presented in the figures from 3.7 to 3.9.

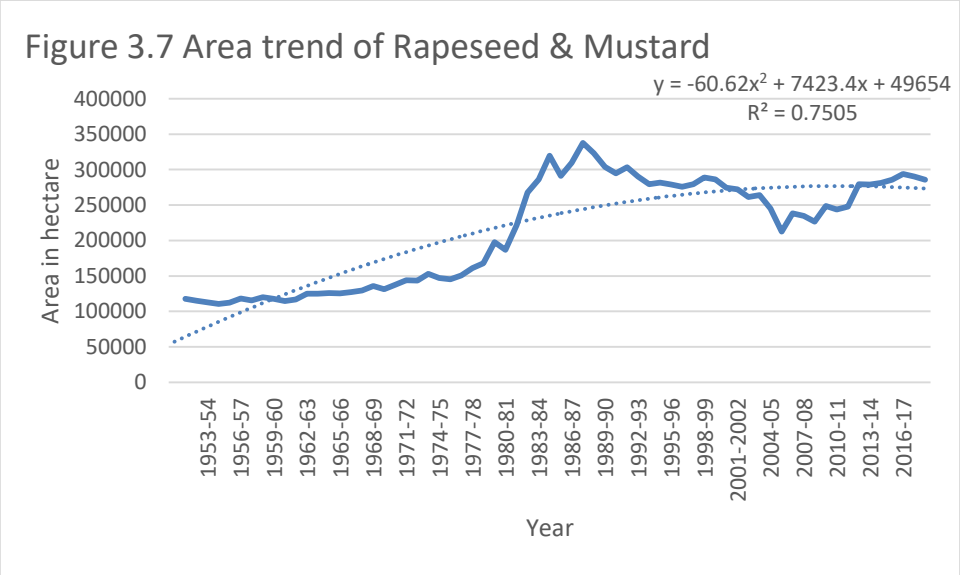


Figure 3.7 Area trend of Rapeseed & Mustard
y = -60.62x² + 7423.4x + 49654
R² = 0.7505
Area in hectare
400000
350000
300000
250000
200000
150000
100000
50000
0
1953-54
1956-57
1959-60
1962-63
1965-66
1968-69
1971-72
1974-75
1977-78
1980-81
1983-84
1986-87
1989-90
1992-93
1995-96
1998-99
2001-2002
2004-05
2007-08
2010-11
2013-14
2016-17
Year

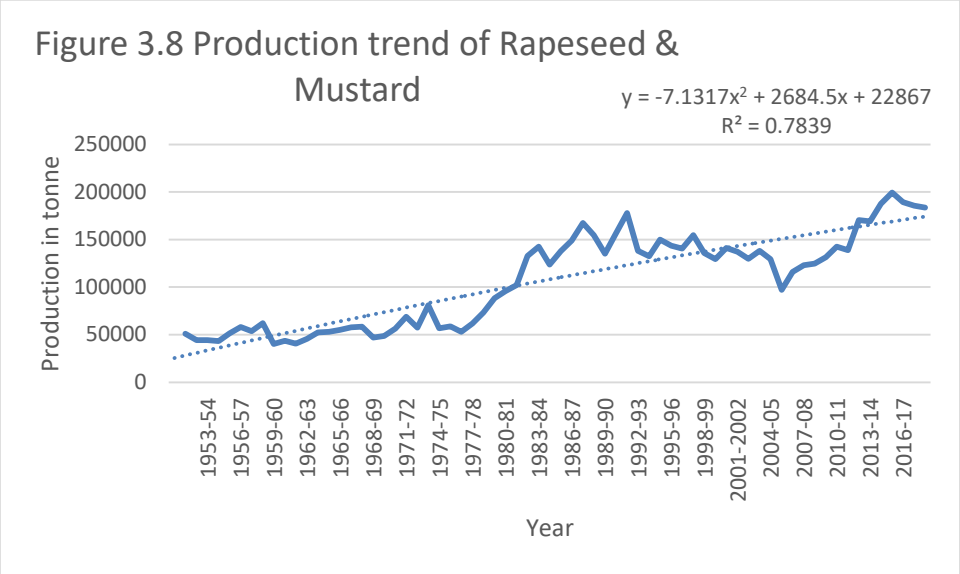


Figure 3.8 Production trend of Rapeseed & Mustard
y = -7.1317x² + 2684.5x + 22867
R² = 0.7839
Production in tonne
250000
200000
150000
100000
50000
0
1953-54
1956-57
1959-60
1962-63
1965-66
1968-69
1971-72
1974-75
1977-78
1980-81
1983-84
1986-87
1989-90
1992-93
1995-96
1998-99
2001-2002
2004-05
2007-08
2010-11
2013-14
2016-17
Year

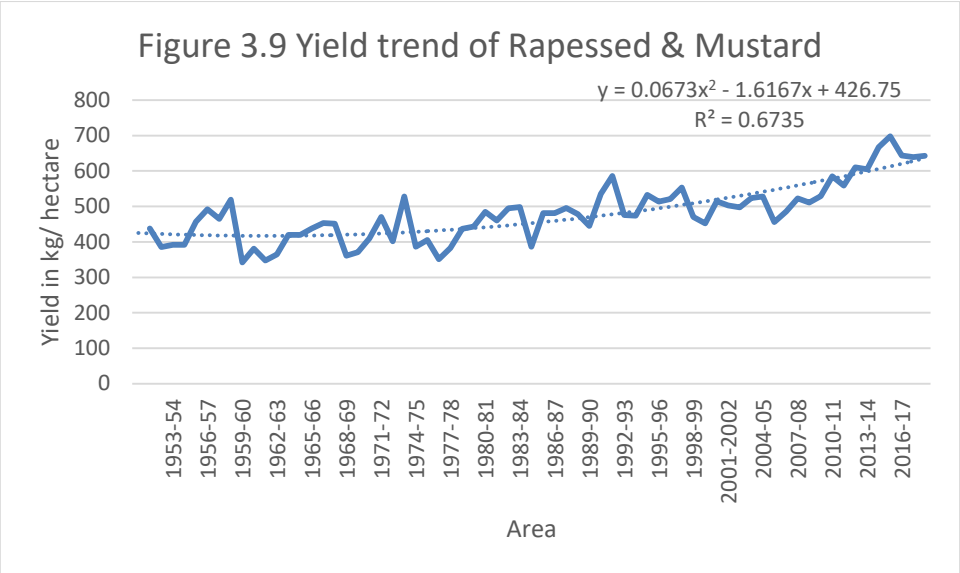


Figure 3.9 Yield trend of Rapessed & Mustard
y = 0.0673x² - 1.6167x + 426.75
R² = 0.6735
Yield in kg/ hectare
800
700
600
500
400
300
200
100
0
1953-54
1956-57
1959-60
1962-63
1965-66
1968-69
1971-72
1974-75
1977-78
1980-81
1983-84
1986-87
1989-90
1992-93
1995-96
1998-99
2001-2002
2004-05
2007-08
2010-11
2013-14
2016-17
Area

Figure 3.7, 3.8, and 3.9 shows the trend curve of area, production, and yield of rapeseed & Mustard in Assam. From these, increasing Trend has been observed for area, production and yield. The slope of the Trend of yield has been observed lower than the Trend of area and production. Hence, it has been concluded that the area contributed more to the production of rapeseed & Mustard in Assam.

Compound Growth Rates (C.G.R) and Growth Instability in Area, Production and Yield:

The direction and degree of growth have been studied by Compound Growth Rate analysis (C.G.R). C.G.R of area, production, and yield of Rice, Jute and Rapeseed & Mustard in the State Assam have been shown in Table 3.5. For calculating C.G.R exponential function has been used, and t-test was used for testing the significance.

To find out the Growth instability, the Coefficient of Variation (C.V) in percentage has been used because of the reason that it quantifies percentage variation in the mean. Accordingly, the C.V of area, production, and yield of Rice, Jute and Rapeseed & Mustard have been found out. The values of coefficient of variation (C.V) of area, production, and yield of Rice, Jute and Rapeseed & Mustard in Assam are shown in same Table 3.5.

Table 3.5: Compound Growth Rate (C.G.R %) of Area, Production and Yield of Rice, Jute and Rapeseed & Mustard in Assam during1951-52 to 2018-19

Crop	Aspects	Compound Growth Rate (%)	Coefficient of Variation (%)
Rice	Area	0.8000**	15.58
	Production	2.000**	41.53
	Yield	1.400**	52.33
Jute	Area	-1.200**	25.99
	Production	-0.500**	31.61
	Yield	0.700**	18.16
Rapeseed & Mustard	Area	1.700**	35.25
	Production	2.300**	45.78
	Yield	0.600**	16.93

From the table, it has been found that the compound growth rate of area, production and yield of Rice, Jute and Rapeseed & Mustard seems significant and positive growth but the area and production of Jute revealed a negative growth rate in Assam. From the value of coefficient of variation (C.V), it has been observed that production of all three crops have higher variation whereas lower variation has been found in the area of Rice followed by Jute and Rapeseed & Mustard. The yield of Rice seems very higher variation in Rice but for Jute and Rapeseed & Mustard shows a stable result because the value of coefficient of variation is less than 20%.

CONCLUSIONS

The present study emphasizes on trend analysis, growth rate and instability of area, production and yield of Rice, Jute and Rapeseed & Mustard in Assam. In this study, different linear and non-linear function was used to fit the best fitted Trend with the help of the value of measures of determination (R^2) and mean square error (MSE). Quadratic functions were found to be best fitted trend equation for the estimation of area, production and yield of selected crops of Assam. The trend analysis results revealed that for all the crops it shows there is an increasing trend for area, production and yield except the area of Jute shows decreasing Trend. Compound growth rate and coefficient of variation was used to check the growth and instability of area, production and yield of selected crops. The compound growth rate of area, production and yield of Rice, Jute and Rapeseed & Mustard seems significant and positive growth but the area and production of Jute revealed a negative growth rate in Assam. From the value of coefficient of variation (C.V), it has been observed that production of all three crops have higher variation whereas minimum variation has been found in area of Rice followed by Jute and Rapeseed & Mustard. The yield of Rice seems very high variation in

Rice but for Jute and Rapeseed & Mustard shows a stable result because the value of coefficient of variation is less than 20%.

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Declaration of interest:
The authors declare that they have no conflict of interest.

Author Contributions:
B.Neog-writing- original draft preparation, data collection, analyzed, organized; B.Gogoi & A.N. Patowary- Visualization and supervision. All authors have read and agreed to the published version of the manuscript.

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