

Growth trend and Instability Analysis of Autumn Rice Cultivation in Assam

Rintu Deka^{1*}, Dr. Mridula Devi²

¹Assistant Professor, Department of Economics, Nalbari College, Nalbari

²Associate Professor, Department of Economics, Bodoland University

ABSTRACT

Rice occupies 71.87 percent of gross crop area and 92.4 percent of total area under food grains cultivation in Assam. This paper examines the trend in growth rate of area, production and productivity of Autumn Rice in Assam based on the latest secondary data for the period of 1990-91 to 2021-22, published by Director of Economics and Statistics, Assam. Annual growth rate, Annual Average Growth Rate and Compound Annual Growth Rate have been estimated to analyse the growth rate of area, production and productivity over the years. Various models such as Linear, Logarithmic, Inverse, Quadratic, Compound, Cubic, S-Curve etc. are used to determine the best fit model for assessing the growth trends. It also examines the instability of Area, Production and Productivity of Autumn Rice using the Coefficient of Variation and Cuddy Della Valle Instability Index. The result indicates a decreasing trend in the growth of area and production and an increasing trend in productivity over the years. This study will help the crop growers and policy makers to take targeted intervention for improvement of Autumn Rice cultivation in Assam.

Keywords: Annual Average Growth Rate, Compound Annual Growth Rate, Production and Productivity, Instability

INTRODUCTION

Autumn rice, locally known as **Ahu rice in Assam**, holds significant importance in the state economy. In the year 2022-23, the area under Ahu Rice was 0.79 lakh hectare which was about 3.5 percent of total rice area in Assam. It is a primary source of income for many rural poor and provides seasonal employment opportunities to millions of Assamese people. Though the economic benefits of Ahu rice are comparatively lower than those of Sali and Boro Rice (Deka, 2015), it holds significant importance in local markets due to its unique characteristics and early harvesting period. Ahu rice is deeply connected to Assamese agricultural traditions; it is used in various traditional Assamese dishes and contributes to the rich culinary heritage of Assam. The main objectives of the present study is to examine the growth rate of Area, Production and Productivity of Autumn Rice in Assam. This will provide valuable insights for initiating policy support like subsidies, training and improved market access.

Singh et al. (2017) studied the Growth Rate and Trend analysis of Wheat Crop in Uttar Pradesh, India. The trend equations in the study were fitted using different growth models, i.e. Linear, Logarithmic, inverse, Quadratic, Cubic, Power, Sigmoid, Growth and Exponential models. It was found that during the period 1971-2010 India experienced a positive trend in the growth rates of Area, Production and Productivity of Wheat. The Linear Growth Rate and Compound Growth Rate of area were 1.00 percent and 1.07 percent, for production they were 1.67 percent and 1.70 percent and for productivity they were 2.48 percent and 2.66 percent respectively.

Mech A. (2017) studied the Growth Trend, Instability and determinants of rice production in Assam over the period 1972-73 to 2013-14. It was found that the growth rate in area, yield and production of rice has remained positive during the period 1972-2014 in case of Assam and India. The annual growth rate of production in Assam was lower than the all-India average of 1.022 percent per annum, which was attributed to the lack of technological breakthroughs, leading to lower productivity in comparison to national level. To estimate the impact of various factors on rice production in Assam, three types of models were used namely linear model, loglinear model and log linear model with autocorrelation corrections. The estimated result of log linear model with autocorrelation corrections shows that among the various determinants influencing rice production during the period 1972 to 2014, the area under rice cultivation in hectares; area covered by HYV Seeds in hectare; and the quantity of the

fertilizers used (in kg per hectare) were found to have a positive and significant impact on rice production in Assam, Temperature was found to have negative impact on rice production.

Das et al. (2007) studied the growth trends in Area, Production and Productivity of Horticulture Crops in Assam. Compound Growth Rates were calculated to find out the growth trends of area, production and productivity of crops. It was found that although there is an increase in area, production and productivity of almost all the crops (except for a negative area, production and productivity growth of papaya; and negative production and productivity growth of brinjal and negative area and production growth of sweet potato), Assam was in a better position for eight crops (banana, litchi, chilly, turmeric, sweet potato, tapioca, cabbage and coconut) regarding production growth. However, the study found high productivity for twelve crops like banana, pine apple, orange, lemon, turmeric, sweet potato, tapioca, cauliflower, tomato, lady's finger, coconut and area nut compared to Indian average. It was also found that the productivity of eleven horticultural crops in Assam has been influenced more by area expansion than by productivity improvement so far. The Study suggested that an increase in production requires an increase in productivity by modern techniques and suitable cropping pattern for sustainable growth in the long run.

METHODOLOGY:

The study is completely based on secondary data collected from various sources. Time series data from 2004-05 to 2021-22 on the Area, Production and Productivity of Rice have been collected from the Directorate of Economics and Statistics, Assam and Directorate of Agriculture - Government of Assam, Statistical Handbook Assam- 2022. To examine the trends in Area, Production and Productivity of Autumn rice in Assam descriptive statistics has been used. To analyze the trends and patterns of growth over the years, the following sets of measure have been used.

$$\text{Annual Growth} = \frac{C_V - P_V}{P_V} \times 100$$

Where,

C_V = Current Value

P_V = Previous Value

$$\text{Average Annual Growth Rate} = \frac{GR_A + GR_B + \dots + GR_n}{N}$$

Where,

GR_A = Growth Rate in Period A

GR_B = Growth Rate in period B

GR_n = Growth Rate in Period n

N = Number of Period

$$\text{Compound Growth Rate} = \left(\left(\frac{EV}{BV} \right)^{1/n} - 1 \right) \times 100$$

Where,

EV = Ending Value

BV = Beginning Value

n = Number of Years

Here in our study, growth of area production and productivity are examined by taking the exponential functional form (Singh et al. 2017; Deka et al., 2018; Hazarika et al., 2021)

$$Y = ab^t$$

$$\text{Or, } \ln y = \ln a + t \ln b$$

Where,

The 'a' and 'b' are parameters

Y= Time series data on input, output (area, production and productivity of dependent variable)

b= Regression coefficient

t= time period in years (Independent Variable)

To compute the Compound Annual Growth Rate (CAGR) following formula is used (Deka et al., 2018; Hazarika et al., 2021)

$$\text{CAGR (r)} = (\text{Antilog } b - 1) \times 100$$

While measuring the agricultural instability, some methods like Coefficient of Variation (CV), Cuddy Della Valle Instability Index (CDVI) and Dispersion etc. can be used (Sihmar, 2014). In the present study the Coefficient of variation and Cuddy Della Valle Instability index are used to measure the instability in the Area, Production and Productivity of Autumn Rice cultivation. John Cuddy and Della Valle developed the Cuddy Della Valle Instability Index to measure the level of instability in time series data (Cuddy and Della Valle, 1978).

$$\text{Cuddy-Della Valle Index} = \text{C.V.} \times [(1 - R^2)]^{0.5}$$

C.V. = Coefficient of Variation

$$\text{Coefficient of Variation (CV)} = (\text{Standard Deviation} / \text{Mean}) \times 100$$

R^2 = ESS/TSS i.e. ratio of explained variation to total variation.

ESS = Variation explained by explanatory variable.

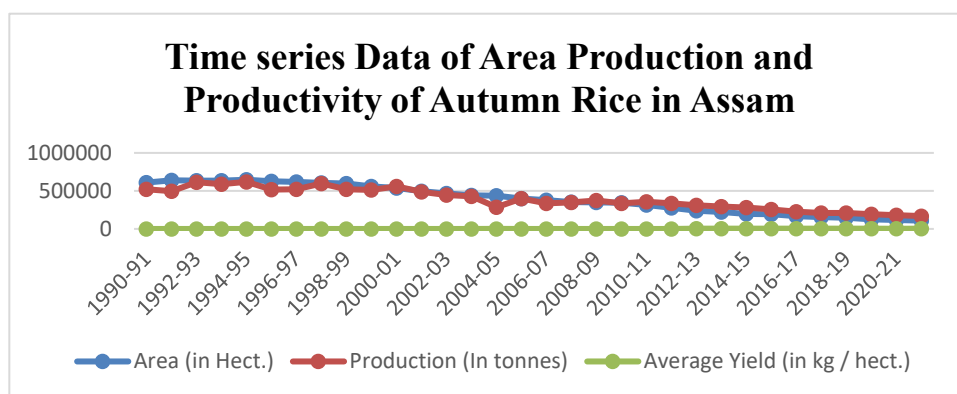
TSS = Total Variation.

Generally, Coefficient of variation is the simplest measure of instability. However, it has some limitations in case of any time series data which exhibits trends as it tends to overestimates the level of instability. To give a clear picture of instability the Cuddy Della Valle Index first detrends the given series. Cuddy-Della Valle index detrends the CV by using coefficient of determination (R^2). Therefore, Cuddy Della Valle Instability Index is considered as one of the best measures for evaluating the level of instability in time series data. The level of instability is directly related to the value of the index. A higher index indicates a higher level of instability and vice versa. The value of CDVI can be defined as (Rakesh Sihmar, 2014) –

- Low instability = between 0 to 15
- Moderate instability = greater than 15 and lower than 30
- High instability = greater than 30

Figure:1 shows the time series data of area, production and productivity of Autumn Rice in Assam from 1990-91 to 2020-21. It has been observed that there is a consistent decline in the area under Autumn rice cultivation since 1998-99. Though production initially fluctuated over the years, a consistent declining trend has been observed since 2010-11. Productivity has relatively stable and has shown a slight increasing trend over the years.

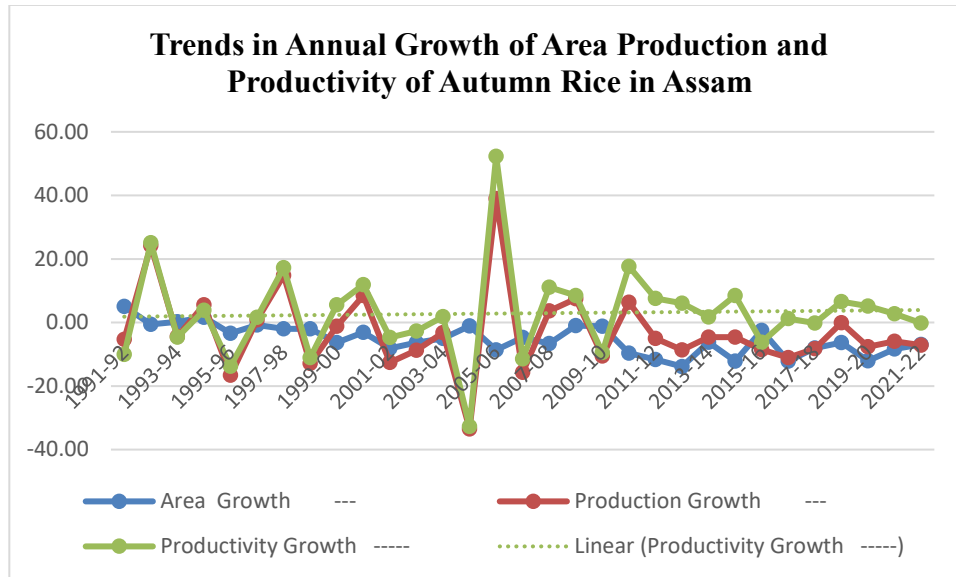
Figure:1



Source: Director of Economics and Statistics, Assam

Figure: 2 shows the trends in annual growth rate of area, production and productivity of Autumn Rice in Assam.

Figure:2



Source: Director of Economics and Statistics, Assam

Table:1 shows the annual growth rate of Area, Production and Productivity of Autumn Rice in Assam from 1990-91 to 2021-22. Except for three years, there was a negative growth rate of Area in other years under Autumn Rice cultivation in Assam. The highest negative growth rate was observed in 2012-13. A negative growth rate was most common in case of production during this period. However, a positive growth rate in productivity was observed in most years. The highest negative growth rate in both production and productivity were recorded in 2004-05, followed by highest positive growth rate in 2005-06.

Table: 1			
Annual Growth of Area Production and Productivity of Autumn Rice in Assam			
Year	Area Growth	Production Growth	Productivity Growth
1990-91	---	---	----
1991-92	5.06	-5.36	-10.08
1992-93	-0.60	24.17	25.10
1993-94	0.22	-4.41	-4.58
1994-95	1.58	5.54	3.84
1995-96	-3.38	-16.65	-13.77
1996-97	-0.83	0.81	1.67
1997-98	-1.98	14.86	17.23
1998-99	-2.04	-12.87	-11.10
1999-00	-6.35	-1.24	5.51
2000-01	-3.15	8.48	11.94
2001-02	-8.15	-12.56	-4.76
2002-03	-6.29	-8.78	-2.70
2003-04	-5.03	-3.24	1.85
2004-05	-1.11	-33.49	-32.69
2005-06	-8.69	39.03	52.32

2006-07	-4.74	-15.67	-11.52
2007-08	-6.67	3.66	11.12
2008-09	-0.98	7.48	8.51
2009-10	-1.22	-10.52	-9.41
2010-11	-9.64	6.33	17.62
2011-12	-11.66	-5.01	7.53
2012-13	-13.86	-8.66	6.04
2013-14	-6.23	-4.63	1.75
2014-15	-12.15	-4.67	8.51
2015-16	-2.48	-8.54	-6.19
2016-17	-12.17	-11.11	1.17
2017-18	-8.05	-8.26	-0.22
2018-19	-6.31	-0.11	6.61
2019-20	-12.12	-7.61	5.11
2020-21	-8.39	-5.95	2.72
2021-22	-6.94	-7.09	-0.19
Data Source: Director of Economics and Statistics, Assam			
Author's own computation			

The table titled 2 gives an overview on the trends in Area, Production, and Productivity of Autumn Rice cultivation in Assam over a longer period of time. It has been observed that the area under autumn rice cultivation has been declining significantly in Assam over the years, with an average annual decline rate of 7 percent. The CAGR is slightly higher than the Annual Average Growth at 8.07 percent. It indicates that interest in Autumn Rice Cultivation has declined. This may be due to a shift in cropping pattern or changes in land use. Although the area has declined sharply, production has declined more moderately with an Annual Average Growth Rate of -2 percent and Compound Annual Growth Rate of -4.18 percent over the years. As the overall trend in production is negative, this indicates a reduction in the total volume of autumn rice produced in Assam over time. However, productivity has shown an upward trend with an Annual Average Growth Rate of 6 percent and Compound Annual Growth Rate of 4.22 percent. In spite of downward trend in Area under cultivation and production, the increasing trend of productivity reflects higher productive capacity per hectare. Probable indicators of increasing productivity include the use of better seeds, improved farming practices or use of modern technology as well as better soil fertility.

Table:2			
Annual Average and CAGR of Autumn Rice in Assam between 2004-05 to 2020-21 (Percentage)			
	Area	Production	Productivity
Annual Average Growth	-7	-2	6
CAGR	-8.07	-4.189	4.22

Data Source: Directorate of Economics and Statistics, Assam

Author's own computation

The instability in Area, Production and Productivity is measured using the Coefficient of variation and Cuddy-Della Valle instability index. This has been depicted in table 3. It has been observed that in case of Autumn Rice cultivation in Assam, the instability indices for area, production and productivity are found to be low. This indicates that the autumn rice cultivation in assam is less risky for crop growers. The instability index for area is lower than that of production and productivity.

Table: 3			
Measures of instability in Area, Production and Productivity of Autumn Rice in Assam			
Measures of Instability	Area	Production	Productivity
Coefficient of Variation (CV)	17.80	35.85	22.81
Cuddy- Della Valle Instability Index	4.78	11.33	8.83
Data Source: from director of Economics and Statistics, Assam			
Author's own calculation			

Table:4 shows the different models used to test the best estimation of growth trends in Autumn Rice cultivation in Assam. In each of these models, Y is the dependent variable, representing value of the variable (Area, Production and Productivity) and X is the independent variable, representing time. Here, b_0 is the intercept (the value of y when $x=0$), b_1 , b_2 , b_3 are the coefficients that determine the influence of the independent variable on the dependent variable

Table:4		
Expression of Models		
Sl.No.	Model	Expression
1	Linear	$Y = b_0 + b_1X$
2	Logarithmic	$Y = b_0 + b_1 \ln(X)$
3	Inverse	$Y = b_0 + \frac{b_1}{X}$
4	Quadratic	$Y = b_0 + b_1X + b_2X^2$
5	Cubic	$Y = b_0 + b_1X + b_2X^2$
	Compound	$Y = b_0b_1^x$
7	Power	$Y = b_0X^{b_1}$
8	Sigmoid (S)	$Y = \exp^{b_0 + \frac{b_1}{X}}$
9	Growth	$Y = \exp^{b_0 + b_1x}$
10	Exponential	$Y = b_0 + \exp^{b_1x}$

Table: 5 shows the different values of coefficients, AdjR^2 and RMSE which used in various statistical models for estimation of area growth in Autumn rice cultivation in Assam. It has been found that the AdjR^2 value of the quadratic model is the highest and it has the lowest RMSE. Therefore, Quadratic model is considered the best fit for the estimating the area growth of Autumn Rice cultivation in Assam during this period. It is noted that all the AdjR^2 values are highly significant at 1% and 5% level of significance.

Table: 5						
Growth Model for the Area of Autumn Rice in Assam:						
Model	b_0	b_1	b_2	b_3	AdjR^2	RMSE
Linear	722889.65	-19884.50			0.93***	28161.62
Logarithmic	881566.01	190988.89			0.74**	92826.10
Inverse	326074.67	541840.83			0.26**	156247.72
Quadratic	699877.78	-15823.59	-123.05		0.96***	13445.79
Cubic	628321.88	8356.36	-1926.98	36.44	0.95***	14245.47

Compound	919016.33	0.94			0.93***	72053.88
Power	1363489.26	-0.54			0.62**	174251.70
S-Curve	12.55	1.46			0.19**	194583.56
Growth	13.73	-0.05			0.93***	72053.88
Exponential	919016.33	-0.05			0.93***	72053.88
Data Source: Director of Economics and Statistics, Assam Author's own computation by using SPSS						

Figure:3 shows the trend line of various models that can be used to estimate the area growth of Autumn Rice Cultivation in Assam. Most of the lines reveal downward trends, indicating a decline in the area growth of Autumn Rice over time.

Figure: 3 Curve estimation of Autumn Rice Cultivation

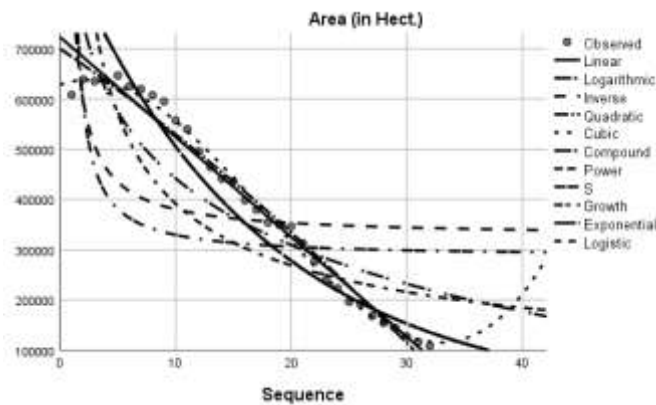


Table:6 shows the different growth models used to examine the best model fit for estimating the production growth of Autumn Rice cultivation in Assam. It has been observed that the quadratic model is best suited for estimating production growth as it has the highest AdjR2 (i.e. 0.90) and lowest RMSE. The AdjR2 is highly significant at 1%level of significance.

Table:6						
Growth Model for the Production of Autumn Rice in Assam:						
Model	b_0	b_1	b_2	b_3	AdjR ²	RMSE
Linear	625129.24	-14161.56			0.89***	44639.25
Logarithmic	732107.87	-133654.92			0.65**	80085.00
Inverse	345843.80	359696.69			0.20**	121013.75
Quadratic	602733.31	-10209.34	-119.76		0.90***	41697.98
Cubic	554482.54	6095.41	-1336.17	24.57	0.89***	43001.17
Compound	699971.16	0.961			0.89***	55099.80
Power	913388.27	-0.35			0.60**	19130.15
S-Curve	12.68	0.94			0.18**	23569.31
Growth	13.45	-0.03			0.89***	9740.36
Exponential	699971.16	-0.03			0.89***	9740.36
Data Source: Director of Economics and Statistics, Assam Author's own computation by using SPSS						

Figure:4 shows the different trends represented by each growth model. Most of the lines are downward sloping,

indicating decreasing trends in the production of Autumn Rice over time.

Figure: 4 Estimation of Growth trends in Production of Autumn Rice in Assam

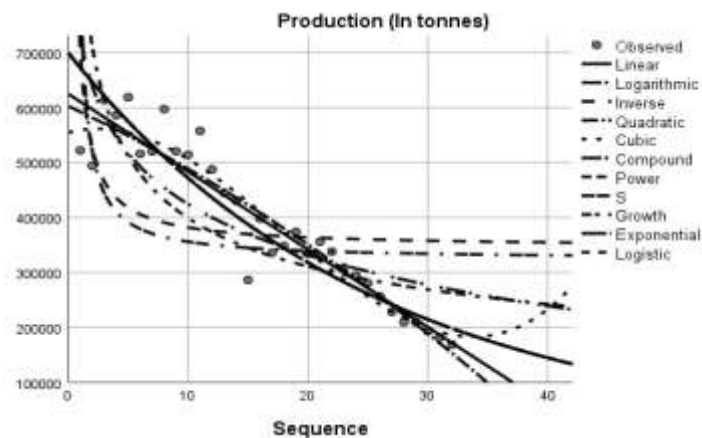
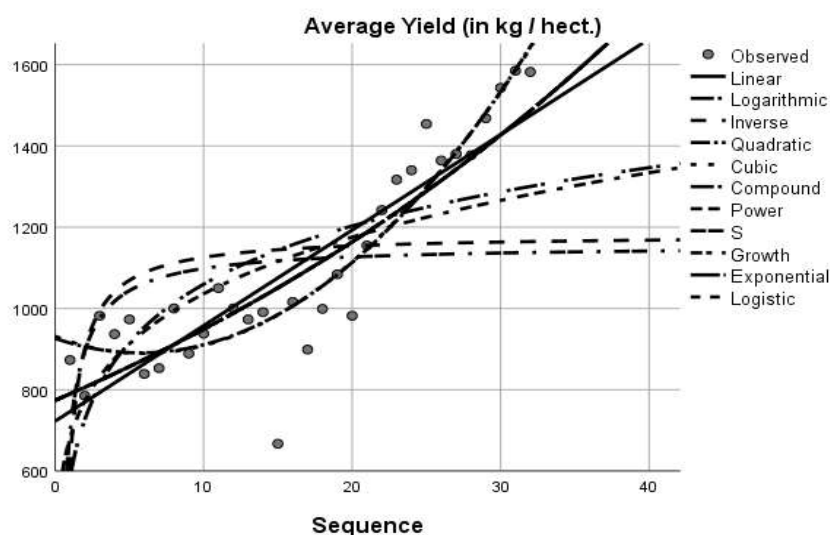


Table:7 shows the different growth models which can be used to estimate the productivity growth of Autumn Rice. It has been found that the cubic model is the best fit for estimating growth trends in productivity, as it has the highest AdjR2 (i.e, 0.85) and the lowest RMSE. The Adj R2 value is highly significant at 1% level of significance.

Table: 7						
Growth Model for the Average Yield of Autumn Rice in Assam:						
Model	b_0	b_1	b_2	b_3	AdjR ²	RMSE
Linear	722.56	23.513			0.74***	122.80
Logarithmic	583.27	206.87			0.47**	178.45
Inverse	1182.18	-564.95			0.14**	226.37
Quadratic	926.32	1.08	-12.44		0.85**	90.54
Cubic	931.59	-14.22	1.22	-0.002	0.85***	90.53
Compound	773.91	1.020			0.71***	112.68
Power	680.64	0.182			0.46**	30.18
S-Curve	7.05	-0.51			0.15**	39.77
Growth	6.65	0.020			0.71**	19.91
Exponential	773.91	0.02			0.71**	19.91
Data Source: Director of Economics and Statistics, Assam						
Author's own computation by using SPSS						

Figure:5 shows different trend lines of different growth models used to estimate productivity growth over time. It reflects an increasing trend in productivity growth, although there have been fluctuations during certain periods.

Figure: 5, Estimation of Growth trends in Average Yield of Autumn Rice Assam**CONCLUSION AND POLICY IMPLICATION:**

From the analysis of the present study on growth trend analysis of Autumn Rice, it can be concluded that the growth of area and production of autumn rice has shown a continuous decline from 1990 to 2021, except during some specific periods. It is possible due to urbanization, crop shifting and changing climate conditions. However, despite the decreasing trends in area and production, in most of the times increasing productivity growth indicates improvements in technology, better inputs usage and modern practices which have led to increase yields per hectare of land. The instability in the growth of area and production can increase the risk to food security and reduce farmers profitability as well as income. Therefore, targeted policy intervention is highly recommended for promoting sustainable agricultural practices, water supply infrastructure and to provide economic incentives to sustain the balanced growth in area, production and productivity of Autumn Rice cultivation in Assam.

REFERENCE:

1. Singh M. and Supriya K. 2017. Growth Rate and Trend Analysis of Wheat Crop in Uttar Pradesh, International Journal of Current Microbiology and Applied Sciences, 6(7):2295- 2301.
2. Mech, A. 2017. An Analysis of Growth Trend, Instability and Determinants of Rice Production in Assam, Indian Journal of Agricultural Research ISSN: 0976-058X
3. Hazarika, M., Sarma, A. and Kaushik K. Phukon (2021) An Analysis of Area Production and Productivity of Banana in Assam, Agricultural Science Digest, 41(2): 334-337
4. Pegu, N.C. 2017. Growth, Instability and Resource Use Efficiency in Production of Rice in Assam: PhD Thesis: 118-119
5. N. Deka, J.P. Hazarika, P.P. Bora and R. Buragohain (2018), Change in Land Use and Cropping Pattern in Assam: An Economic Analysis, Economic Affairs, 6(1): 39-43
6. Manavendra Singh and K. Supriya. 2017. Growth Rate and Trend Analysis of Wheat Crop in Uttar Pradesh. Int.J.Curr.Microbiol.App.Sci. 6(7): 2295-2301
7. Cuddy, J.D.A. and Valle, P.A.D. (1978). Measuring the instability of time series data. Oxford Bulletin of Economics and Statistics. 40 (1): 79-85
8. Sihmar, R. (2014). Growth and instability in agricultural production in Haryana: A district level analysis. International Journal of science and Research Publications. 4(7): 1-12
9. Hazarika, M. et al. 2021. An Analysis on Area Production and Productivity of Banana in Assam. Agricultural Science Digest, Volume 41 Issue 2: 334-337