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TRENDS IN AREA, PRODUCTION AND PRODUCTIVITY OF GROUNDNUT CROP BASED ON LINEAR AND NON-LINEAR MODELS FOR BANASKANTHA DISTRICT BEFORE AND AFTER BT COTTON INTRODUCTION

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ABSTRACT

The time series data on area, production and productivity of groundnut crop for 31 years were collected for Banaskantha district for the period 1985-86 to 2015-16 from Directorate of Agriculture, Gandhinagar, Gujarat State. The entire study period was divided into two sub-periods on the basis of introduction of Bt- cotton as pre Bt-cotton i.e. period I (1985-1986 to 2001-2002) and post Bt- cotton i.e. period II (2002-2003 to 2015-2016). Various polynomial as well as ARIMA models were used to study the growth in area, production and productivity of groundnut crop in Banaskantha district. The results revealed that cubic model during period I, overall period, power model during period II for area, whereas cubic model for period I, ARIMA (1, 1, 1) during period II and ARIMA (3, 2, 3) during overall period for production and cubic model during period II as well as during overall period for productivity were the best fitted.

Keywords: *Bt- cotton, area, production, productivity, polynomial model and ARIMA*

INTRODUCTION

Groundnut (*Arachis Hypogaea* L.) is important oilseed crop among the major oilseed crops. India is one of the world's largest producer of groundnut (Rai *et al.,* 2020 and Sardhara *et al.,* 2020). India has the largest area (4596.33 thousand hectare) with production (6733.33 thousand metric tonnes) and productivity (1465 kg/ha) under groundnut in the world during 2016-17. Gujarat is the largest producer of groundnut in India contributing 43 per cent of the total production during 2016-17 (Anon., 2017c). Japanese biologist, Shigetane Ishiwatari was first discovered *Bacillus thuringiensis* (*Bt*-cotton) in 1901 which was approved in India in March 2002 after stringent assessment for biosafety and profitability. The area under *Bt*-cotton increased from 0.4% to 40% in India, in a short period of four years (2002-2006). (Anon., 2016).

In India, area under cotton was about 1634800 hectares with production of 1684600 bales and productivity about 175 Kg per hectare during the year 2002-03 which increased to 3010000 hectares, 11089000 bales and 627 Kg per hectare respectively during the year 2014-15. It shows increment of 84.12 per cent, 558.25 per cent and 258.28 per cent in area, production and productivity respectively. (Anon., 2016)

The present study was conducted to study the impact of *Bt*- cotton on area, production and productivity of groundnut in Banaskantha district of Gujarat.

OBJECTIVES

(1) To study different statistical models for the growth in area of groundnut crop in Gujarat.

(2) To study different statistical models for the growth on production of groundnut crop in Gujarat.

(3) To study different statistical models for the growth on productivity of groundnut crop in Gujarat.

METHODOLOGY

Nature and source of the data

The time series data on area, production and productivity of groundnut for 31 (1985-86 to 2015-16) years were collected for Banaskantha district of Gujarat state from Directorate of Agriculture, Gandhinagar, Gujarat State. The entire study period was divided into two sub-periods on the basis of introduction of *Bt*- cotton as pre *Bt*-cotton *i.e.* period I (1985-1986 to 2001-2002) and post *Bt*- cotton *i.e.* period II (2002-2003 to 2015-2016).

Different models to study trend in area, production and productivity of groundnut

Different regression equations such as Linear, Logarithmic, Inverse, Quadratic, Cubic, Power, Compound, Growth and Exponential were fitted for Banaskantha district with respect to area, production and productivity. The model with highest values of R^2 and adjusted R^2 was considered as the best model.

Test of significance for regression coefficients

The null hypothesis about regression coefficients was tested

$H_0: \beta_i = 0$

$H_a: \beta_i \neq 0$

With the test statistic

$$t = \frac{b_i}{SE(b_i)}$$

Where, calculated t was compared with table t at 5% and 1% level of significance value with (n-k-1) degrees of freedom.

Autoregressive (AR) and Moving Average (MA) models (Pankratz, 1983)

Autoregressive (AR) process

This model is in the same form as the well-known simple linear regression model in which Y_t (Z_t) is the dependent variable and Y_{t-1} is the explanatory variable.

$$Z_t = C + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + ... + \varphi_p Y_{t-p} + a_t \quad .... (1)$$

Where Z_t= Time sequenced random variable

C = Constant term related to mean (μ) such that C = μ (1- φ_1)

φ_i = Relationship of Y_p with Y_{t-p}

a_t = A random shock element at time t

Moving Average (MA) process

$$Z_t = c - \grave{e}_1 a_{t-1} + \grave{e}_2 a_{t-2} + ... + \grave{e}_q a_{t-q} + a_t \quad ...(2)$$

Where C = constant term related to mean μ and θ_i = relation of a_q with a_{t-q}

Fitting of box-jenkins ARIMA models

Box-Jenkins time-series models i.e. ARIMA (p, d, q) is known as "Univariate Box-Jenkins technique" (Box and Jenkins, 1976) ARIMA model is an algebraic statement telling how observations on a variable are statistically related to past observation.

This model amalgamates three types of process, viz., Autoregressive of order p; differencing to make a series stationary of degree d and moving average of order q. This method applied only to a stationary time series data. When the data is non-stationary then it has to be brought into stationary by the method of differencing.

Test for stationarity

The stationarity requirement ensures that one can obtain useful estimates of the mean, variance and ACF from a sample. The stationarity condition of a series was tested by examining the

1. The change of mean and variance over time.

2. The coefficients of AR and MA process i.e. in case of AR (1) and MA (1) process it should be $|\varphi_1|<1$ and $|\theta|<1$.

3. The estimated ACF values which should be tails-off towardszero rapidly.

The significance of autocorrelation was tested by t-test. The standard error of autocorrelation (Bartlett, 1946) was calculated as under

$$s(r_k) = \left(1 + 2\sum_{j=1}^{k-1} r_j^2\right)^{1/2} n^{-1/2} \quad ....(3)$$

$$t_{r_k} = \frac{r_k - \tilde{n}_k}{S(r_k)} \quad ....(4)$$

K=1, 2, 3…The significant value of "t" indicates the presence of autocorrelation.

ARIMA modelling consists of three operational steps:

i. Identification

The foremost and widely used tool in identification stage is the estimated ACF and PACF's were compared to find a match and correlograms which are simply the plots of ACFs and PCFs against the lag length. The tentative ARIMA model, whose theoretical ACF and PACF best match with the estimated ACF and PACF was chosen. In choosing a tentative model, the principle of parsimony is followed *i.e.* a model that fits the given realization with the smallest number of estimated parameters.

ii. Estimation

Estimating the parameters for Box - Jenkins models is a quite complicated in non - linear estimation problem. For this reason, the parameter estimation should be left to a high quality software program that fits Box Jenkins models. The main approaches for fitting Box-Jenkins models are non-linear least squares and maximum likelihood estimation.

iii. Diagnostic checking

The best model was selected on the basis of minimum valuesof Schwartz-Bayesian Information Criterion (SBC) and Akaike Information Criterion (AIC) the Ljung and Box test was used for independent.

RESULTS AND DISCUSSION

Linear and non-linear models for area under groundnut

The results related to the linear and non linear models for area during period I revealed cubic model was the best fitted model as it gave the highest value of Adj. R^2 (0.58) with positive and significant quadratic term indicating the positive growth rate in area under groundnut crop during period I. Similarly, during period II, quadratic model and power model showed maximum value of Adj. R^2 (0.94) but power model was considered as the best fitted since it have significant coefficient while quadratic model have non significant coefficients. Positive and significant coefficient in power model indicates the increasing trend in area under groundnut in Banaskantha district during period II. While for overall period, cubic model was the best fitted model for the area under groundnut in Banaskantha district as it gave maximum value of Adj. R^2 (0.96) with positive and highly significant coefficients in the models indicating the increasing trend in area under groundnut in Banaskantha district.

Fitting of time series models for area

The new variable X_t was constructed by taking differences of one (*i.e.* d=1) for period I, period II and overall period to make the series stationary. There is no appropriate fitting of ARIMA for area in Banaskantha district for period I and period II as the autocorrelation (Υ_k) and partial autocorrelation (φ_{kk}) did not cut-off after any lag.

For overall period, the ACF (Υ_k) of the transformed variable was damping towards zero with cut off at first spike and the PACF (φ_{kk}) also cut-off at first lag. This suggested that the algebraic family of ARIMA on p =0,1 d= 1 and q=0,1 can be used. Among the fitted ARIMA models, ARIMA (0, 1, 1) model was the best fitted as it had comparatively lower values of AIC (7.80) and SBC (7.99) with higher value of Adj.R^2 (0.94) indicating positive trend as it had positive and significant MA (q) coefficient.

Comparison of the linear and non linear models with the ARIMA models showed that the cubic model during period I and overall period while power model during period II were the best fitted models indicating increased area under groundnut in Banaskantha district.

Similar results *i.e.* the increasing trend in area under groundnut was also reported by Chada (1967), Wasim (2001), Sonnad (2011), Parmar (2012), Ramachandra *et al.* (2013), Kumar and Sehgal (2015), Suseela and Chandrasekaran (2016) and Shruthi *et al.* (2017).

Fitting of linear and non-linear models for production of groundnut

The linear and non linear models fitted for production during period I revealed that the cubic model was best fitted with highest value of Adj. R^2 (0.58) having positively non significant coefficients indicating no growth in production of groundnut in Banaskantha district during period I.

Fitting of time series models for production

The new variable X_t was constructed by taking differences of one (*i.e.* d=1) to make the series stationary for period I and period II. The ACF (Υ_k) of the transformed variable was damping towards zero with cut off at first spike and the PACF (φ_{kk}) also cut-off at first lag. This suggested that the algebraic family of ARIMA on p =0, 1, d= 1 and q=0, 1 can be used. Among the fitted models, ARIMA (0, 1, 1) and ARIMA (1, 1, 1) models were the best fitted for period I and period II, respectively as it had comparatively lower values of AIC (5.25 and 11.30, respectively) and SBC (5.32 and 11.38, respectively) with higher value of and Adj. R^2 (0.38 and 0.78, respectively) indicating positive trend as it had positive MA (q) coefficient.

The new variable X_t was constructed by taking differences of twice (*i.e.* d=2) to make the series stationary as original and first differenced series was also found to be non stationary. The ACF (Υ_k) of the transformed variable was damping towards zero with cut off at first, second and third spike and the PACF (φ_{kk}) also cut-off at first, second and third lag. This suggested that the algebraic family of ARIMA on p =0,…,3 d= 2 and q=0,…,3 can be used. Among the fitted models, ARIMA (3, 2, 3) model was the best fitted as it had comparatively lower values of AIC (10.15) and SBC (10.35) with higher value of Adj. R^2 (0.87) indicating positive trend as it had positive MA (q) coefficient.

Comparison of the linear and non linear models with the ARIMA models showed that the cubic model for period I indicating no growth, whereas ARIMA (1, 1, 1) for period II and ARIMA (3, 2, 3) for overall period were the best fitted models indicating positive trend for the production of groundnut in Banaskantha district.

The increase in area under groundnut might be responsible for increased production in Banaskantha district.

Table 1: Trends in area, production and productivity of groundnut crop based on linear and non-linear models for Banaskantha district

	Area																	
	Period I						Period II						Overall					
	Constant	B	C	D	R^2	Adj. R^2	Constant	B	C	D	R^2	Adj. R^2	Constant	B	C	D	R^2	Adj. R^2
Linear	12.51	1.13			0.41	0.37	-60.07	46.45			0.94	0.93	-133.33	17.14			0.68	0.67
Quadratic	9.46	2.10	-0.05		0.42	0.34	7.79	24.17	1.45		0.95	0.94	101.19	-25.27**	1.31**		0.94	0.93
Cubic	7.10	3.32	0.42*	0.01	0.66	0.58	-41.24	57.75	-3.96	-0.24	0.95	0.93	10.18	5.70	-1.01	0.05**	0.97	0.96
Compound	14.60	1.05**			0.38	0.34	78.46	1.17**			0.93	0.92	4.42	1.18**			0.96	0.95
Inverse	25.23	-12.50			0.11	0.05	421.58	-549.63**			0.49	0.45	188.46	-333.06			0.11	0.08
Logarithmic	10.28	6.30*			0.31	0.26	-114.28	226.86**			0.79	0.77	-209.78	323.23**			0.41	0.39
Power	10.32	0.38*			0.37	0.33	20.43	1.29**			0.95	0.94	0.001	4.05**			0.96	0.95
Exponential	14.60	0.05*			0.38	0.34	78.46	0.15**			0.93	0.92	4.42	0.16**			0.96	0.95
Growth	2.68	0.05*			0.38	0.34	4.36	0.15**			0.93	0.92	1.58	0.16**			0.96	0.95
	Production																	
	Period I						Period II						Overall					
	Constant	B	C	D	R^2	Adj. R^2	Constant	B	C	D	R^2	Adj. R^2	Constant	B	C	D	R^2	Adj. R^2
Linear	5.55	1.82			0.48	0.44	-151.52	83.43**			0.71	0.69	-248.28	29.65			0.57	0.56
Quadratic	-0.87	3.85	-0.11		0.51	0.44	67.88	1.16	5.48		0.75	0.70	175.73	-47.44	2.41**		0.82	0.81
Cubic	17.71	-7.01	1.35	-0.05	0.66	0.58	-79.97	102.41	-10.82	0.72	0.76	0.69	-44.27	29.05	-3.47	0.12*	0.86	0.84
Compound	10.99	1.07**			0.42	0.38	91.92	1.20**			0.75	0.73	3.49	1.21**			0.85	0.84
Inverse	27.52	-27.58			0.24	0.20	692.57	-940.15			0.33	0.27	299.32	-562.88			0.09	0.06
Logarithmic	0.28	10.99**			0.43	0.39	-243.68	398.97**			0.56	0.52	-362.20	233.57**			0.31	0.29
Power	5.04	0.69*			0.49	0.46	12.92	1.70**			0.75	0.73	5.08	4.94**			0.86	0.85
Exponential	10.99	0.07*			0.42	0.38	91.92	0.18**			0.75	0.73	3.49	0.19**			0.85	0.84
Growth	2.40	0.07*			0.42	0.38	4.52	0.18**			0.75	0.73	1.25	0.19**			0.85	0.84
	Productivity																	
	Period I						Period II						Overall					
	Constant	B	C	D	R^2	Adj. R^2	Constant	B	C	D	R^2	Adj. R^2	Constant	B	C	D	R^2	Adj. R^2
Linear	603.71	36.42*			0.18	0.12	591.70	167.98			0.29	0.23	298.24	65.55			0.34	0.32
Quadratic	417.34	95.28	-3.27		0.20	0.09	1912.58	-327.35	33.02		0.44	0.34	990.03	-60.23	3.93		0.42	0.38
Cubic	461.48	69.46	0.22	-0.13	0.20	0.01	378.79	1241.79	-219.70	11.23	0.64	0.53	-19.96	290.95	-23.07	0.56	0.51	0.45
Compound	661.80	1.04			0.16	0.10	622.14	1.13**			0.38	0.33	425.16	1.06**			0.41	0.39
Inverse	1087.91	-772.93			0.17	0.11	2269.98	-1801.49			0.12	0.05	1571.46	-1727.53			0.10	0.07
Logarithmic	442.50	248.13			0.20	0.15	511.35	744.82			0.20	0.13	-106.39	576.96**			0.23	0.20
Power	512.78	0.29			0.20	0.15	448.24	0.71			0.26	0.20	110.97	0.89**			0.32	0.30
Exponential	661.81	0.04			0.16	0.10	622.14	0.12			0.38	0.33	425.16	0.06**			0.41	0.39
Growth	6.49	0.04			0.16	0.10	6.43	0.12			0.38	0.33	6.05	0.06**			0.41	0.39

*, ** Significant at 5% and 1% levels, respectively

Table 2: Fitting of time series models for area, production and productivity of groundnut crop in Banaskantha district

Particular	ARIMA (p, d, q)	constant	AR(p)	MA(q)	R^2	Adj. R^2	AIC	SBC	Box – Ljung
Area (Overall)	(1,1,0)	-21.15	-0.40	--	0.94	0.93	8.01	8.07	12.87
	(0,1,1)	**-22.73**	**--**	**0.51***	**0.95**	**0.94**	**7.80**	**7.99**	**12.67**
	(1,1,1)	-22.67	-0.03	0.49	0.95	0.93	8.08	8.15	12.60
Production (Period I)	(1,1,0)	2.83	-0.54*	--	0.31	0.29	5.65	5.80	10.44
	(0,1,1)	**3.45**	**--**	**1.00**	**0.40**	**0.38**	**5.25**	**5.32**	**12.80**
	(1,1,1)	3.16	0.16	0.99	0.40	0.36	5.30	5.37	10.37
Production (Period II)	(1,1,0)	8.95	-0.78	--	0.71	0.68	11.40	11.55	13.60
	(0,1,1)	24.84	--	0.99	0.68	0.65	11.56	11.64	14.33
	(1,1,1)	**-4.36**	**-0.60***	**0.99**	**0.82**	**0.78**	**11.30**	**11.38**	**13.35**
Production (Overall)	(1,2,3)	-5.60	-0.57	0.62	0.87	0.85	10.55	10.63	6.90
	(3,2,2)	-6.88	-0.18	0.96	0.89	0.87	10.25	10.40	11.50
	(3,2,3)	**-5.94**	**-0.70**	**0.09**	**0.90**	**0.87**	**10.15**	**10.35**	**7.94**
Productivity (Period II)	(0,1,1)	-386.90	--	0.99	0.26	0.20	14.69	14.81	14.50
	(1,1,0)	-441.88	-0.79	--	0.18	0.11	14.85	14.93	13.93
	(1,1,1)	**-543.69**	**-0.99**	**0.96**	**0.38**	**0.27**	**13.78**	**13.90**	**9.35**
Productivity (Overall)	(1,1,1)	-216.04	-0.96	-0.63	0.36	0.31	13.87	13.97	9.34
	(1,1,2)	**-33.05**	**-0.96***	**0.77**	**0.47**	**0.41**	**13.82**	**13.95**	**7.63**
	(2,1,1)	-72.63	0.28	0.29	0.47	0.41	14.01	14.10	7.86

*, ** Significant at 5% and 1% levels, respectively

Similar results *i.e.* the increasing trend in production under groundnut was also reported by Chada (1967), Wasim (2001), Kachroo (1993), Sonnad (2011), Parmar (2012), Datarkar *et al.* (2015), Kumar and Sehgal (2015), Suseela and Chandrasekaran (2016) Ranjana *et al.* (2017), Samal *et al.* (2017) and Shruthi *et al.* (2017).

Fitting of linear and non-linear models for productivity of groundnut

The results for productivity during period I showed that none of the models were best fitted for the trend in productivity of groundnut for Banaskantha district as they have very low values of Adj. R^2.

The result for productivity during period II showed that cubic model was best fitted with the highest value of Adj. R^2 (0.53) having positively and non significant coefficients which indicates the positive growth in productivity of groundnut in Banaskantha district during period II.

The result for productivity during overall period showed that the cubic model was the best fitted for the productivity of groundnut in Banaskantha district for overall period with maximum value of Adj. R^2 (0.45) with positive and non significant regression coefficients indicating the positive growth in productivity of groundnut in Banaskantha district.

Joshi (2009) also reported the cubic model as the best fitted model for the productivity under groundnut crop.

Fitting of time series models for productivity

The autocorrelation (Υ_k) of the original variable was tail-off towards zero but the autocorrelation (Υ_k) and partial autocorrelation (φ_{kk}) did not cut-off after any lag. This suggested that there is no appropriate fitting of ARIMA for productivity in Banaskantha district during period I.

The new variable X_t was constructed by taking differences of one (*i.e.* d=1) to make the series stationary for period I and overall period. The ACF (Υ_k) of the transformed variable was damping towards zero with cut off at first spike and the PACF (φ_{kk}) also cut-off at first lag for period II. This suggested that the algebraic family of ARIMA on p =0, 1, d=1 and q=0, 1 can be used. Among the fitted models, ARIMA (1, 1, 1) model was the best fitted with comparatively lower values of AIC (13.78) and SBC (13.90) with higher value of Adj. R^2 (0.27) indicating positive trend as it had positive MA (q) coefficient for period II.

The ACF (Υ_k) of the transformed variable was damping towards zero with cut off at first and second spike and the PACF (φ_{kk}) also cut-off at first and second lag for overall period suggesting the algebraic family of ARIMA on p =0,…, 2, d= 1 and q=0,…, 2 can be used. Among the fitted models, ARIMA (1, 1, 2) model was the best fitted with comparatively lower values of AIC (13.82) and SBC (13.95) with higher value of Adj. R^2 (0.41) indicating negative trend as it had negative and significant AR (p) coefficient for overall period.

Comparison of the linear and nonlinear models with the ARIMA models showed that none of the model was best fitted for period I while cubic model period II and overall period was best fitted indicating positive trend for the productivity of groundnut in Banaskantha district.

The increased area and productivity of groundnut is responsible for increased production of groundnut in Banaskantha district.

CONCLUSIONS

It is concluded that introduction of *Bt*- cotton has no influence on area, production and productivity of groundnut in Banaskantha district as area, production and productivity of groundnut is showing increasing trend in post *Bt*- cotton period.

POLICY IMPLICATIONS

(1) To maintain acreage at desired levels, appropriate price policy measures should be adopted so that the oilseeds crop growers can obtain remunerative prices of their produce.

(2) There is a need to improve the productivity of oilseed crops through more research and extension efforts.

CONFLICT OF INTEREST

There is no conflict between author.

REFERENCES

Anonymous, (2016). Indiastat. Available at http://www.indiastat.com > accessed 15 June, 2018.

Chada, R. S. (1967). Growth rates in Indian agriculture. *Agricultural Situation in India.* 22: 51-57.

Datarkar, S.; Pagire, B. V.; Darekar, A. and Hile, R. B. (2015). Region wise compound growth rates in area, production and productivity of kharif groundnut in Maharashtra. *International Journal of Tropical Agriculture.* 33(2): 1101-1106.

Joshi, B. D. (2009). Statistical models to study the growth and instability in oilseed production of Karnataka. Unpublished *M.Sc. Thesis,* University of Agricultural Sciences, Dharwad.

Kachroo, K. K. (1993). Growth and instability of oilseeds production. *Indian Journal of Agricultural Economics.* 48(3): 334-338.

Kumar, M. and Sehgal S. (2015). Trends in area, production and productivity of non food grains in India. *International Journal of Research.* **2(2):** 993-1001.

Rai, A. K., Khajuriaand, S. and Kanak Lata (2020) Impact of front line demonstrations in transfer of groundnut production technology in semi arid region. *Guj. J. Ext. Edu.* 31(1):6-10.

Sardhara, A. D., Jadav, N. B. and Zala, P. H. (2020) Constraints in adoption of recommended plant protection practices in groundnut and cotton crops. *Guj. J. Ext. Edu.* 31(2):47-51.

Parmar, S. (2012). Study of growth, instability and supply response of commercial crops in Punjab: an econometric analysis. *Journal of Reasearch in Arts and Education.* 1(5): 49-53.

Ramachandra, V. A.; Basanayak, R.T.; Salunke, R. and Ravusaheb, M. (2013). Growth in area, production and productivity of major crops in Karnataka. *Internationl Research Journal of Agricultural Economics and Statistics.* 4(2): 117-123.

Ranjana, A.; Thakar, K. P.; Burak, S. S. and Arti, A. (2017). Production and export performance of Indian groundnut. *Indian Journal of Agricultural Science.* 9(4): 3724-3727.

Samal, S. P.; Patra, R. N.; Das, M. K.; and Nanda, B. B. (2017). Growth and instability in oilseed production in Odisha: a district level analysis. *International Jouranl of Humanities and Social Science Invention.* 6(11): 39-45.

Shruthi, G.; Rao, B. D.; Devi, Y. L. and Masi, J. (2017). Analysis of the area, production and productivity of groundnut crop in Telangana. *Agricultural Science Digest.* 37(2): 151-153.

Sonnad, J. S. (2011). Growth analysis of oilseed crops in India during pre and post - WTO periods. *Karnataka Journal of Agricultural Sciences.* 24(2): 184-187.

Suseela, K. and Chandrasekaran, M. (2016). Growth and instability in dryland agriculture of Andhra Pradesh. *International Journal of Agricultural Science and Research.* 6(2): 285-294.

Wasim, M. P. (2001). Growth and variability in major crops production in China. *Pakistan Journal of Applied Economics.* 17(1/2): 45-70.

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