ISSN: 0974-5823 Vol. 7 No. 5 May, 2022

International Journal of Mechanical Engineering

A SUGARCANE PRODUCTION IN TAMILNADU USING A COMPARISON OF ARIMA, STATE SPACE AND LINEAR MIXED MODELS

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Abstract

This paper attempts forecasting the sugarcane area, production and productivity and sugar production of India and as well as major sugarcane production of Tamilnadu through fitting of univariate Auto Regressive Integrated Moving Average (ARIMA) models. The data on sugarcane area, production, productivity and sugarcane yield forecasting time series analysis and state space models individually could provide the suitable relationship to reliably forecast the sugarcane production in Selam, Namakkal, Erode, Coimbatore and Krishnagiri districts of Tamilnadu. collected from the data are collected and analysis of chronologically 1961-2015.has been used for present study of the performances of models are validated by comparing with actual values in sugarcane area, production and productivity of Tamilnadu have been forecasted using A Comparison Auto Regressive Integrated Moving Average (ARIMA) models, State space model and linear mixed model

Key words: *Forecasting, Sugarcane Production, state space models, (ARIMA) models, linear mixed model, Tamil Nadu.*

1. Introduction

Sugarcane is a adaptable crop. Sugarcane juice is main raw material for sugar industries. Byproducts of sugar industry are also playing important role in the national economy. Molasses, the chief by-product, is the main raw material for alcohol and alcohol based industries in the country. Another by-product Bagasse is used as fuel, for production of fibre board, papers, plastics and furfural (Biswal, 2013). Green tops of cane are good source of fodder for cattle Also sugarcane stubbles are good sources of manure in alkaline and saline soils. Because of its diversified uses in different industries, this crop is considered as wonder cane (Suresh and Krishna. 2011).

Cultivation of sugarcane in India dates back to Vedic period. The earliest mention of sugarcane cultivation in Indian literature is found during the period 1400 to 1000 B.C. It is now widely accepted that India is the original home of Saccharum species. India is the second largest producer of sugarcane, next to Brazil. Production of sugarcane in India is about 339 million tons from an area of 5064 thousand hectare in 2012. Though, Indian productivity (71.60 tonnes per ha) is higher than average world productivity of 70.24 tonnes, it stands fortieth in world ranking against 127.81 tonnes per ha of Peru, stands first and is almost double than of India.

Working out the reason for such dismal picture is most warranted to take up any sugarcane improvement programme. The major producers of sugarcane in the country during 2012 are Uttar Pradesh (43 percent), Maharashtra (15 percent), Tamil Nadu (10 percent), Karnataka (8 percent) which together share about 76 percent of total sugarcane production while remaining 24 percent is contributed by Andhra Pradesh, Punjab, Haryana, Gujarat etc. The figure for the year 2012, indicted that there are about 529 working sugar factories in India with a production capacity of 26.34 million tonnes of sugar. India exported about 4074.90 thousand metric tonnes of sugar, worth Rs.129737.3 million and imported about 119.661 thousand metric tonnes of sugar of value 3746.7 million in 2012.

As sugarcane occupies a significant position among the commercial crops in India, a proper forecast of production of such important commercial crops is very important in an economic system. There is close association between crop productions with prices. An unexpected decrease in production reduces marketable surplus and income of the farmers and leads to prices rise. A glut in production can lead to a slump in prices and has adverse effect on farmers' incomes. Impact of price of an essential commodity has a significant role in determining the inflation rate, wages, salaries and various policies in an economy. In case of commercial crops like sugarcane, production level also affects raw material cost of user industries and their competitive advantages in the market. Thus, from these point of view study of production and other behaviour for the past and assessment of the same in future play vital role.

The present study focus on the modelling and forecasting of area, production and yield of sugarcane and sugar production for major sugarcane growing states of India as well as India as whole. Sugarcane, a traditional crop of India plays an important role in agricultural and industrial economy of the country. It is cultivated in most of the states and though it covers an insignificant share of about 2 and 20% of gross cropped area of our country and world respectively, its share in our country's economic growth has become significant. Among the sugarcane growing states in our country, Tamilnadu ranks first in per hectare productivity of sugarcane with 113.9/ha of cane yield. Sugarcane is a versatile crop. Because of its diversified uses in different industries, this crop is considered as ''Karpagavirucham'' and in modern terminology as ''wonder cane'' (Mohan et al. 2007).

Sugarcane occupies a significant position among the commercial crops in Tamilnadu. A proper forecast of production of such important commercial crops is very important in an economic system. Impact on price of an essential commodity has a significant role in determining the inflation rate, wages, salaries and various policies in an economy. In case of commercial crops like sugarcane, production level affects raw material cost of user industries and their competitive advantages in the market. In our present study sugarcane area, production and productivity of Tamilnadu have been forecasted using Auto Regressive Integrated Moving Average (ARIMA) models, State space model and linear mixed model

2. Methodology

The Primary purpose of this study was to develop an objective methodology for preharvest sugarcane yield prediction in Tamilnadu. Sugarcane yield forecast models have been devoleped using ARIMA, State space model and linear mixed model procedures and an emphasis has been given to campare the forecasting performance of the alternative models.

The different statistics have been used comparison and validation of the fitted models. These are presented as follows,

The coefficient of Determination (R^2) is in general use for checking the adequacy of the model is given the formula

$$R^2 = 1 - \frac{SS_{res}}{SS_t}$$

Where SS_{res} and $SS_t$are the residual sum of squares and the total sum of squares respectively.

$$R^2_{ads} = 1 - \frac{SS_{res}/(n-p)}{SS_t/(n-1)}$$

Where $SS_{res}/(n-p)$ is the residual mean square and $SS_t/(n-1)$ is the total mean square.

Relative Deviation(RD%)

This measures the deviation of predicted yield from the observed yield . the formula for calculating the percent deviation of forecast is given by

$$Percent\ deviation = \{(Observed\ yield) - predicted\ yield/Observed\ yield\} * 100$$

Root Mean Square Error (RSME)

It is used as a measure of comparing two models and the formula of RSME is given as

$$RSME = \left[\left\{\frac{1}{n}\sum_{i=1}^{n}(O_i - E_i)^2\right\}\right]^{\frac{1}{2}}$$

Mean Absolute Percent Error (MAPE)

MAPE is also used to compare the accuracy of prediction capability and is defined as

$$\text{MAPE} = \frac{100}{\text{n}}\sum_{\text{i=1}}^{\text{n}}\left|\frac{O_i - E_i}{O_i}\right|$$

Where $O_i$and E_i are the observed and predicted values of sugarcane yield and n is the number of years for which prediction has been done.

The sugarcane yield production of ARIMA, State space and linear mixed models have been separately used to predict the sugarcane yield of 2014 to 2019 in Tamilnadu. The model predicted yield(s) have been compared with corresponding Department of Agriculture (DOA) yield estimates for the post sample periods 2015, 2016, 2017, 2018 and 2019 based on ARIMA and SS models were obtained to check the validity of the developed models. Finally, a comparison among ARIMA, state space and linear mixed models has been done on the basis of MAPE, RMSE and RD% etc.

3. Comparison of the fitted three models.

The sugarcane yield prediction of the post-sample years 2014 to 2019 were obtained on the basis of fitted ARIMA, State space and linear mixed models. The predictive performance(s) of the conducting models were observed in terms of percent deviations of sugarcane yield forecasts in relation to observed yield(s) and RMSEs as well. The level of accuracy achieved by the state space models was considered adequate i,e. the State Space models consistently showed the superiority over ARIMA and linear models in capturing percent relative deviation pertaining to sugarcane yield pertaining to sugarcane yield prediction in the districts under consideration. The SS models performed well performed well with lower error metrics as compared to the alternative models in all times regimes. A comparative view on estimated yields and percent relative deviation is shown in table 1 and Figure 1 also reflects the same view. RMSEs of the post-sample yield forecasts based on alternative models are given in Table 2.

Table 1:

Sugarcane yield estimates along with observed yield(s) and percent relative Deviations based on alternative models.

Forecast Year(s)	Observed Year(q/ha)	ARIMA		State Space		Linear Mixed	
		Estimate Year(q/ha)	RD(%)	Estimate Year(q/ha)	RD(%)	Estimate Year(q/ha)	RD(%)
Selam							
2015	79.77	71.52	10.34	72.48	9.14	69.60	12.75
2016	78.38	72.2	7.88	74.92	4.41	70.29	10.32
2017	81.6	72.87	10.70	76.52	6.22	70.93	13.07
2018	78.81	73.55	6.67	78.68	0.16	71.56	9.20
2019	85.04	74.22	12.72	79.51	6.50	72.18	15.12
Namakkal							
2015	74.16	66.19	10.89	72.78	2.13	74.87	-0.56
2016	69.90	65.89	6.24	74.87	-7.89	75.64	-8.52
2017	77.78	66.90	13.16	73.89	4.42	76.57	0.37
2018	75.67	67.42	11.84	75.34	-0.48	77.56	-2.48
2019	81.76	67.95	16.78	75.85	7.44	78.19	3.84
Erode							
2015	75.43	73.48	2.64	74.66	2.42	70.36	7.65
2016	83.48	77.01	8.40	79.04	4.78	71.34	14.87
2017	74..67	76.56	-3.80	81.38	-9.57	72.39	2.60
2018	76.37	78.63	-1.62	80. 87	-4.09	72.14	5.83
2019	83.46	78.38	5.66	82.45	0.64	73.84	11.41
Coimbatore							
2015	67.40	69.48	-3.28	66.38	1.78	67.09	0.45
2016	71.63	70.78	1.45	70.01	1.54	68.44	4.78
2017	79.06	71.45	10.36	73.25	7.94	69.04	13.84
2018	71.34	72.45	-1.42	68.57	3.25	69.08	1.84
2019	70.45	73.67	-4.87	69.73	0.72	70.46	-0.45
Krishnagiri							
2015	68.89	65.34	4.67	68.29	-0.46	60.47	11.44
2016	66.47	69.08	-5.43	65.77	0.84	60.74	8.29
2017	74.98	68.54	6.65	67.49	8.40	60.45	17.60
2018	68.48	70.14	-2.84	70.30	-2.84	60.47	11.04
2019	69.84	70.23	-1.83	69.73	0.74	61.34	12.83

Figure 1: Sugarcane yield estimates along with observed yields based on ARIMA state space and linear mixed models.

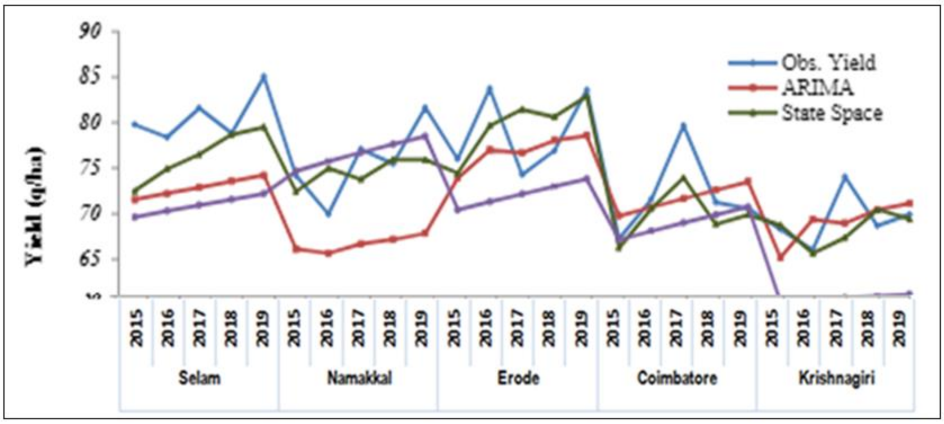

Table-2:

RSMEs of post-sample sugarcane yields prediction based on alternative models.

Districts	**RSMEs**		
	ARIMA	**State Space**	**Linear Mixed**
Selam	8.45	4.89	11.32
Namakkal	9.76	3.49	5.74
Erode	4.78	4.42	13.50
Coimbatore	4.12	3.56	7.26
Krishnagiri	3.07	3.65	12.34

Thus a perusal of the results indicates the performance of using sugarcane yield prediction based on state space models in comparison to ARIMA and linear mixed models. In addition, the developed models are capable of providing the reliable estimates of sugarcane yield well in advance of the production harvest while.

4. Conclusion

An attempt has been made to examine the accuracy of the selected model by comparing the last two data observations with the values obtained by fitting the selected models for the Different forecast models for sugarcane production were built up using statistical techniques ARIMA, state space and linear mixed modeling with different variance covariance structures. In this paper sugarcane production of Tamilnadu and are estimates, Percent relative deviations and comparative view on the results achieved from all procedures and table1 and 2 provide the result achieved by state space and linear mixed modeling followed by comparative view on the fitted models from three different perspectives. The district under consideration were grouped into sugarcane production in Selam, Namakkal, Erode, Coimbatore and Krishnagiri districts of Tamilnadu for building LMMs. The emphasis was given in predicting the future values on the basis of previous time series observations for all the procedures and their predictive performance were comparatively evaluated. The time series data from 2014 to 2019 of sugarcane production was used for the training set used for the validity testing of developed ARIMA, state space and linear mixed models.

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