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Research Paper

Forecasting of green chilli prices in West Bengal by holt-winters method using expert system

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ABSTRACT : The present study was conducted to access the market trend of green chilli in West Bengal using user friendly expert-system. Windows operating system and MS Office package is required to run the system. Triple exponential smoothing (Holt-Winters method) has been applied for forecasting the monthly price of chilli. To measures the accuracy, mean absolute percentage error (MAPE), mean absolute error (MAE) and mean square error (MSE) at different levels of smoothing constants such as α, β and γ have been used for the model selection criteria that can describe the trend the price of green chilli during January 2010 and March 2017. Price of green chilli from April 2016 to March 2017 was considered for model validation. Price forecasts of green chilli from April 2017 to March 2018 were found to be in between Rs.16/kg to Rs. 58/kg highest price forecast during Sept. 2017 and lowest during May, 2017. Upper control limit and lower control limit along with forecast value has given an narrow range of forcast that proves its accuracy in forcasting.

KEY WORDS : Green chilli price, Forecasting, Holt-winters method, Expert-system

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INTRODUCTION :

Agriculture in India has shifted from production based agriculture to market based agriculture where farmers should grow depending on the market price. To predict the market price for their agricultural produce they need to know the market trend. But, the fluctuations in market price due to season hinder the farmers to get higher profit for their produce. To predict the market price, exponential smoothing has proven through the years to be very useful in many forecasting situations. It was first suggested by Holt (1957) and was meant to be used for non-seasonal time series showing no trend. Later Holt (1958) offered a procedure that handle trends (Chatfield, 2013). Winters (1960) generalized the method to include seasonality, hence the name "Holt-Winters Method" or triple exponential smoothing (Gelper *et al.*, 2010 and Bermudez *et al.*, 2010).

Application of the Holt-Winters Method for predicting price of their produce will not be an easy task for a medium educated farmer. A user friendly expert-system for predicting the market trend might be a useful tool for the farmers who can themselves predict the market price in advance. Therefore, a study had been undertaken to develop a user friendly expert-system that will forecast market trend in green chilli using Holt-Winters method.

MATERIALS AND METHODS :

Windows 7 operating system, MS office 2007 and Visual Basic 6.0 have been used to develop the system. Evolutionary model (Successive Version Model) has been adopted to develop the expert-system. In this model, the system is first broken down into several modules or functional units that can be incrementally implemented. Initially, the core module of the system is developed. Then new functional units have been added in with successive versions. Each successive version of the product is a functioning system capable of performing some useful work.

The monthly price of chilli from major markets of West Bengal (*i.e.*, Ramkrishnapur (Howrah), Burdwan, Haldibari, Nadia, Sealdah Koley Market, Dhupguri, Baxirhat, Falakata, Chakda, Barasat, Siliguri) for the period from January 2010 to March 2017 were taken into consideration for the study from the secondary data source from AGMARK (2017).

Model selection procedure:

Single Exponential Smoothing Method is used where no trend or seasonal pattern is followed and Double Exponential Smoothing Method is used when linear trend and no seasonal pattern is followed. Triple Exponential Smoothing (Holt-Winters Method) is appropriate when trend and seasonality are present in the time series. It decomposes the times series down into three components: base, trend and seasonal components (Fig. A). If trend and seasonality are both present in a given set of data, the best method is the Holt-Winters method (Ishaque and Ziblim, 2013; Gelper *et al.*, 2010 and Bermudez *et al.*, 2010). Chakrapani and Kannaiah (2012) had used Holt-Winter method for price forecasting in gold.

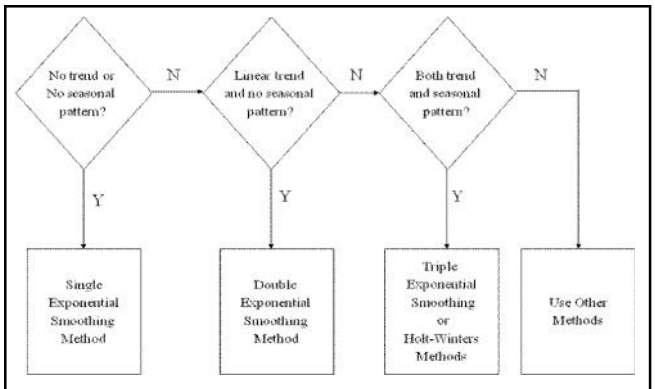


Fig. A : Flowchart to select appropriate model

When an actual observation is divided by its corresponding seasonal factor, it is said to be "deseasonalized" (*i.e.*, the seasonal component has been removed). This allows us to make meaningful comparisons across time periods. The relevant formulas for this method follow:

Overall smoothing:

$$S_t = \sim (y_t / I_{t-L}) + (1-\sim) (S_{t-1}+b_{t-1})$$

Trend smoothing :

$$b_t = :(S_t - S_{t-1}) + (1- \quad) b_{t-1}$$

Seasonal smoothing :

$$I_t = ¥ (y_t /S_t) + (1-¥) I_{t-L}$$

Forecast :

$$F_{t+m} = (S_t + b_t) I_{t+m-L}$$

where,

y is the price of chilli

S is the smoothed observation

b is the trend factor

I is the seasonal index

F is the forecast at m periods ahead

t is an index denoting a time period

L is the number of period in a cycle (12 months of year)

α, β and γ are smoothing constants between 0 and 1 that must be estimated in such a way that the mean square error (MSE) is minimized. These smoothing constants have been used in sliding bar for flexible change of value (Fig. B).

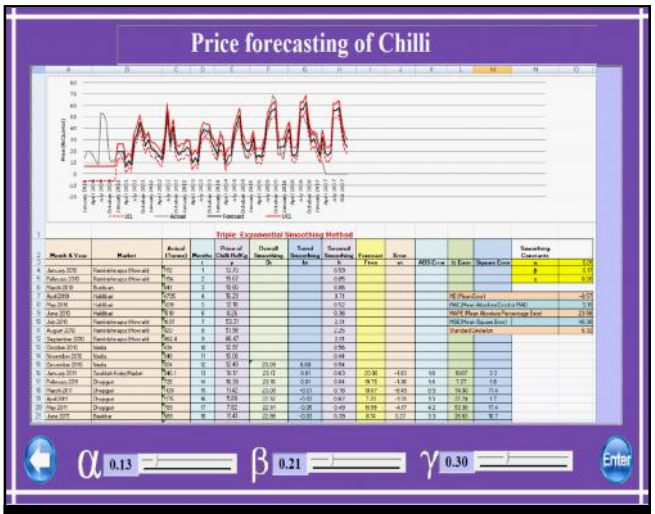
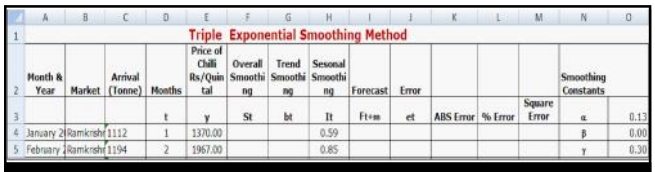


Fig. B : Forecasting module of the Expert-system

Step-by-step triple exponential smoothing analysis using expert system:

Triple exponential smoothing method for analysis using expert-system has been shown in Fig. C. Monthly price of chilli has been taken as input data and yearly season (months) *i.e.*, L=12. The first step is to transform or deseasonalize the first year price data in E4:E15. So the formula has been used $S_t=y_t/[(1/L)(y_1+y_2+---+y_L)]$ in cell H4 which is **=E4/(Average($E$4:$E$15)** in cell H4 and fill down to H15. Then we assume and enter $S_t=(y_1+y_2+---+y_L)/L$ in cell F15 and b_t =0 in cell G15.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Triple Exponential Smoothing Method														
2	Month & Year	Market	Arrival (Tonne)	Months	Price of Chilli Rs/Quintal	Overall Smoothing	Trend Smoothing	Sesonal Smoothing	Forecast	Error				Smoothing Constants	
3				t	y	St	bt	It	Ft+m	et	ABS Error	% Error	Square Error	α	0.13
4	January 2	Ramkrishn	1112	1	1370.00			0.59						β	0.00
5	February 2	Ramkrishn	1194	2	1967.00			0.85						γ	0.30

Fig. C : Columns of the data table

Overall smoothing:

For overall smoothing, $S_t = \sim (y_t / I_{t-L}) + (1-\sim)(S_{t-1}+b_{t-1})$ was used in F16 cell for which, formula has been entered **=$O$3*(E16/H4)+(1-$O$3)*(F15+G15)** and filled down till F90.

Trend smoothing:

For trend smoothing, $b_t = \ \ =(S_t - S_{t-1}) + (1- \ \ ) b_{t-1}$ was used in cell G16 for which, formula has been entered = **$O$4*(F16-F15)+(1-$O$4)*G20** and filled down till G90.

Seasonal smoothing:

For seasonal smoothing $I_t = ¥ (y_t / S_t) + (1-¥) I_{t-L}$ was used in cell H16 for which, formula has been entered **=$O$5*(E16/F16)+(1-$O$5)*H4** and filled down till H90.

Forecast:

Now combining all three formulas together we make $F_{t+m} = (S_t + b_t) I_{t+m-L}$ and put it in I16 which is **=(F15+G15)*H4** and fill down upto I99.

Mean absolute error, mean square error, mean absolute percentage error:

The mean absolute error (MAE), mean squared error (MSE) and mean absolute percentage error (MAPE) calculations were inserted in column K, L and J, respectively.

Mean absolute error (MAE) $=\frac{1}{n}\sum_{t=1}^{n}|y_t-\hat{y}_t|$ was used in P4 cell for which, formula has been entered = **SUMSQ (K15:K90) / COUNT (K15:K90).**

Mean square error (MSE) $=\frac{1}{n}\sum_{t=1}^{n}(y_t-\hat{y}_t)^2$ was used in P6 cell for which, formula has been entered **=SUMSQ (J15:J90) / COUNT (J15:J90)**

Mean absolute percentage error (MAPE) $=\frac{1}{n}\sum_{t=1}^{n}\frac{|y_t-\hat{y}_t|}{y_t}$ **x100** was used in P5 cell for which, formula has been entered **=AVERAGE (L16:L90)**

where, y_t = Actual price and $\hat{y}_t$ = Predicted price.

Smoothing constant:

An equivalent component of solver has been created to minimize the mean absolute error (MAE) and to find a better value or to optimize the forecast. Three separate sliding bars generate value for the smoothing constants α, β and γ within the range from 0 to 1. The value of α, β and γ constraints were calculated in the cell P4, P5 and P6, respectively in the expert-system. To forecast the price for 1st month, $F_{t+m} = (S_t + b_t) I_{t+m-L}$ was used in I91 cell for which, formula has been entered = **(F90+1*G90)*H79.** Similarly, for next 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th and 12th month's forecast the subsequent formulas were entered.

RESULTS AND DATA ANALYSIS :

The data from different markets of West Bengal shows the time series plot of chilli price (Fig. 1). The actual price of chilli recorded during the study period was highest price in September 2015 (Rs. 68.75/kg) and was lowest in April 2011 (Rs.5.89/kg) with a little upward trend during the study. The study shows that there had been a seasonal fluctuating trend in each year.

The forecasting of green chilli prices in West Bengal were done through Triple exponential smoothing model. The forecasted prices of green chilli from April 2017 to March 2018 were shown in with Lower Control Limit (LCL) and Upper Control Limit (UCL). The result shows that highest forecasted price for green chilli per kilogram was recorded in Sept., 2017 (Rs.58) with LCL and UCL between Rs. 52 and Rs. 64 whereas lowest forecasted price for green chilli was recorded in May, 2017 (Rs.16) with LCL and UCL between Rs.10 and Rs. 23. UCL and LCL along with forecast value has given an narrow range of forcast that proves its accuracy in forcasting (Fig. 2). The forecasts revealed that the prices of dry

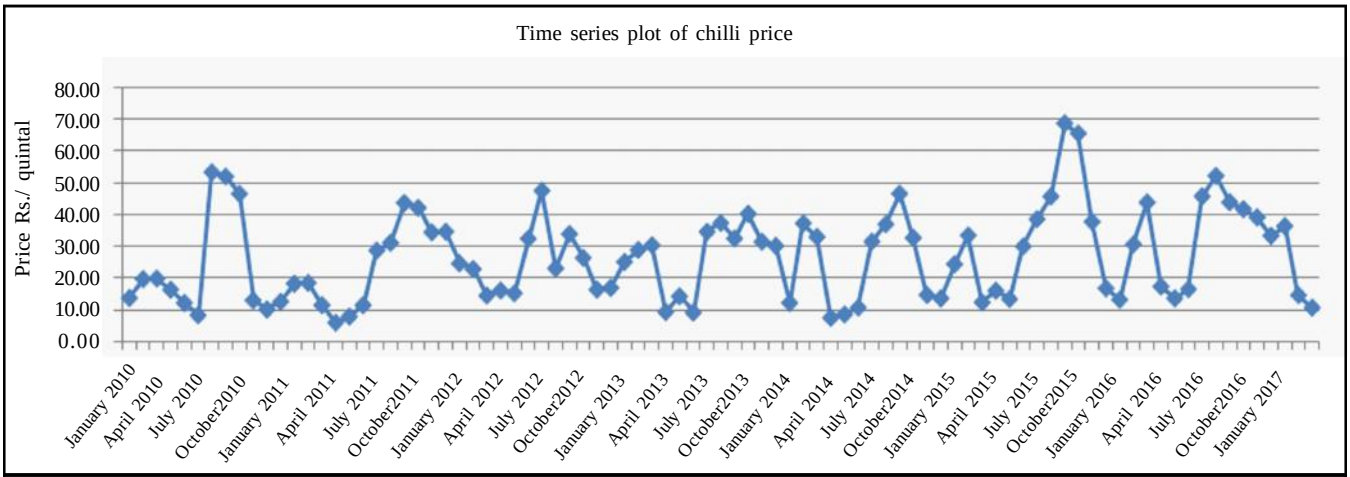


Fig. 1 : Time series plot of chilli

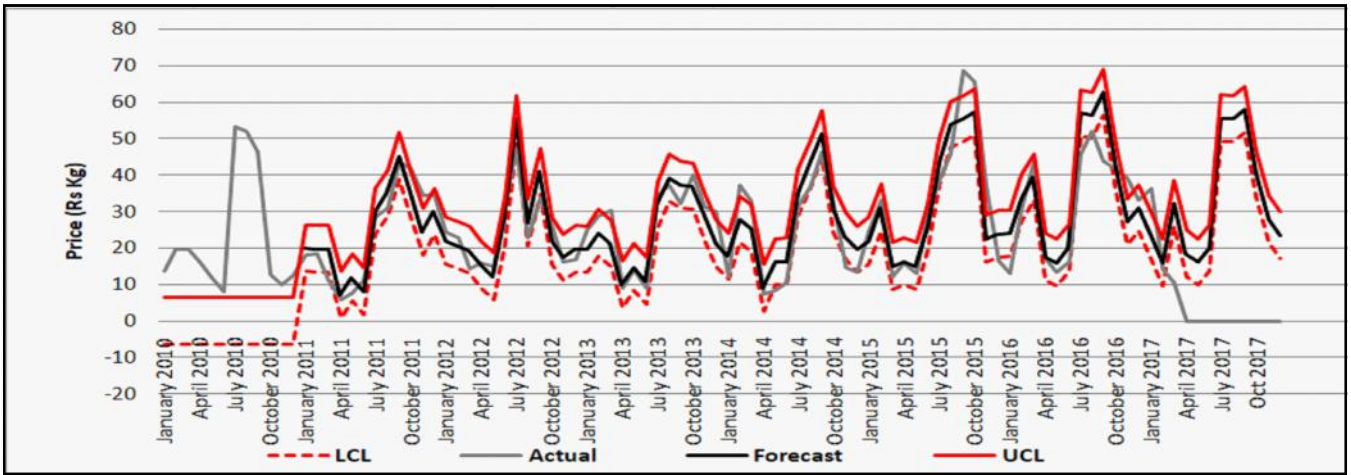


Fig. 2 : Triple exponential smoothing plots for chilli

chilli per quintal would be in the range of Rs. 5,473 to Rs. 5,456 for the months commencing from April to July 2013 (Ramya Lakshmi and Bhavani Devi, 2017). Similarly Dhakre *et al.* (2016) had reported The forecasted prices of Brinjal for Feb. 2016 to Sep. 2016 were Rs.10.6, Rs.10.1, Rs.14.9, Rs.15.3, Rs.20.3, Rs.21.5, Rs.21.9 and Rs.21.0 per kg, respectively.

The MAE in cell P4 has been minimize and is equal to 5.19 and the a in cell P4 = 0.01

The MAPE in the cell P5 has been minimize and it is equal to 23.56 and the β in cell P5 =0.17

The γ in cell P5= 0.20 We have optimized smoothing constants to minimise the error.

The prices of chilli during last 12 months *i.e.*, from April 2016 to March 2017 have been considered for model validation where we observed that the forecasted price and the actual price of chilli in West Bengal were nearly equal (Fig. 3). Therefore, it might be stated that the model

Table 1 : Forecasted prices of chilli for different months in West Bengal

Months	April 2017	May 2017	June 2017	July 2017	Aug. 2017	Sept. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Jan. 2018	Feb. 2018	Mar. 2018
LCL	12	10	14	45	49	52	34	22	17	17	21	17
Forecast	19	16	20	52	56	58	40	28	24	23	27	23
UCL	25	23	26	58	62	64	47	34	30	29	33	30

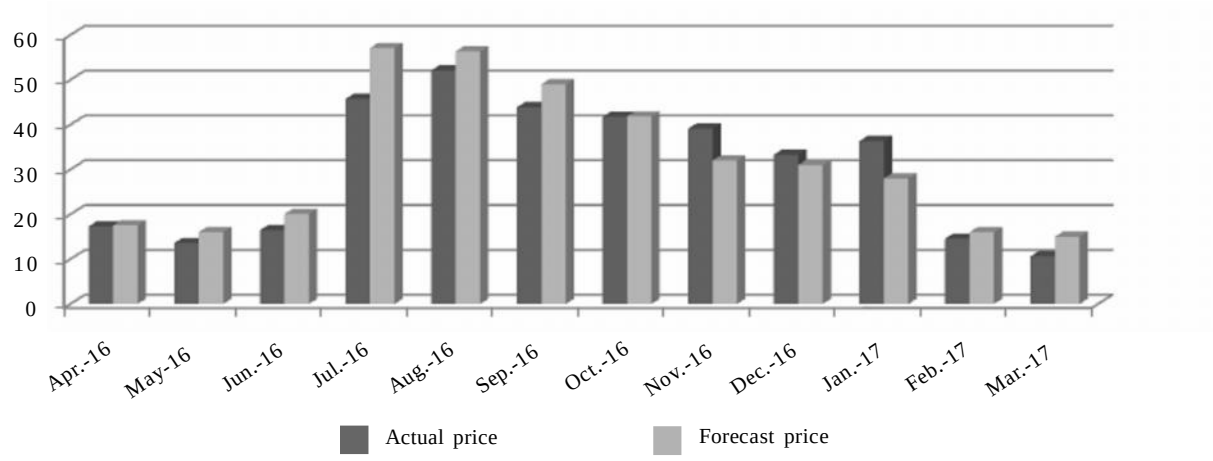


Fig. 3 : Model validation with actual price and forecast price

used for forecasting the price of green chilli in West Bengal was valid.

Conclusion:

The study showed that Holt-Winter method was appropriate for price prediction of green chilli in West Bengal. Similarly other crops whose market price is also effected by seasonality may be predicted in advance using this Holt-Winter methods. Using of the method has been made easy for the medium and high educated farmers using this expert system. Therefore, the extension agencies and the NGOs working in the study area need to use this software for better understanding of the market trend and forecast price for vegetable growers in the study area for getting higher return of their agricultural produce.

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