Advances in Bioresearch
Adv. Biores., Vol 10 (4) July 2019: 10-18
©2018 Society of Education, India
Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
DOI: 10.15515/abr.0976-4585.10.4.1018

Advances in Bioresearch

ORIGINAL ARTICLE

Time Series investigation of Turmeric in India

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ABSTRACT
Turmeric is having so many medical importance as well as various health issue. India is known for the largest producer and exporter of turmeric in the world. Turmeric occupies about 6% of the total area under spices and condiments in India. Present investigation time series data has used for turmeric area, production, productively of major states of India to meet the objective of study. Hazell model has been used to study the instability of turmeric. Forecasting is important prospect for policy implication and future planning. In this study forecasting has done by using GARCH and ARIMA model. After that both the model has been compared and best model use for trace the future trend. On the basis of forecasting figures ,it can be observe that Andhra Pradesh would be play vital role with 540 '000 t and 6154 kg/ha in production and productivity respectively in India.
Keywords: *Instability, Hazell model, ARIMA, GARCH, Forecasting*

Received 14.05.2019 Revised 28.06.2019 Accepted 06.07.2019

How to cite this article:
K. Padmanaban, P. Mishra , B. S. Dhekale and P.K. Sahu. Time Series investigation of Turmeric in India. Adv. Biores., Vol 10 [4] July 2019. 10-18.

INTRODUCTION

Turmeric (*Curcuma longa*) is native to Asia and India. Turmeric is very important spice in India, which produces nearly entire whole world's crop and consumes 80% of it. India is by far the largest producer and exporter of turmeric in the world. Turmeric occupies about 6% of the total area under spices and condiments in India [2]. The main turmeric producing states in India are Andhra Pradesh, Tamil Nadu, Orissa, Karnataka, West Bengal, Gujarat and Kerala. Maximum area under turmeric cultivation is in Andhra Pradesh (69.9 thousand ha), where production is very high *i.e.* 518.5 thousand tons. Then comes Tamil Nadu (area 25.9 thousand ha and production is 143.3 thousand tons), followed by Orissa and West Bengal (area is 24.0 thousand ha and 11.8 thousand ha respectively. whereas production is 57 thousand tonnes and 25 thousand tonnes respectively (Spices Board of India, Cochin Asha Latha *et al.* [3] studied Hazell [6] model on changes in important cereal production. This modes is time tested model which decomposes variance of production into direct effects and indirect effects, it has unique feature in that the variance of production is decomposed into ten components. The analysis has been done at state level data. Production variability has been measured in two time periods. Paul *et al* [11] attempted India's volatile spice export data through the Box-Jenkins Autoregressive integrated moving average (ARIMA) approach. Subsequently, Generalized Autoregressive Conditional Heteroscedastic (GARCH) nonlinear time-series model along with its estimation procedures are thoroughly studied. Sahu and Mishra [12] studied forecasting the production, import- export (both in quantity and value) and trade balance of total spices in India and China along with world using Autoregressive Integrated Moving Average (ARIMA) model for time series data covering the period of 1961- 2009 and forecasted for year 2020. Mishra *et al.* [8, 9] forecasted for black pepper and cumin respectively. Present study in related to investigation of turmeric instability and forecasting in production in major states in India.

MATERIAL AND METHODS

To meet the objective of present investigation the area, production and productivity of major spices namely Turmeric, in India, national level and by following the relative contribution of each and every states production to total India production, the major growing states for turmeric have been selected for the study purpose. For turmeric the selected major states are Andhra Pradesh, Karnataka, Maharashtra, Odissa and Tamil Nadu and data used 1971- 2014.

Descriptive statistics

Descriptive statistics are used to summarize and describe data. Descriptive statistics quantitatively describe the main features of collected information. Descriptive statistics are distinguished from inferential statistics (or inductive statistics), in that descriptive statistics aim to summarize a sample, rather than use the data to learn about the population that the sample of data is thought to represent.

Instability analysis by Hazell Decomposition Model

Changes in variability and the components of change in variance remained major importance in study of the production behaviour of any crop.

Hazell [6] gave the more advanced decomposition model for studying variance of production. The Hazell model of decomposition has a unique feature in that the variance of production is decomposed into ten components. The change in average production between two periods has also four components. The Hazell decomposition procedure is given below.

Let P denote production, A denote the area sown under a particular crop and Y is the yield per hectare. Then for each crop the total output in the state is P = A * Y. The variance of production, V(P) can be expressed as

$$V(P) = \overline{A}^2 V(Y) + \overline{Y}^2 V(A) + 2\overline{A}\,\overline{Y}\operatorname{cov}(AY) - \operatorname{cov}(AY)^2 + R \text{ ----- (1)}$$

where $\overline{A}$ and $\overline{Y}$ denote mean area and mean yield respectively. R denote the residual term which is expected to be small.

It is clear from the above equation that V(P) is not only the function of variance of yield and area sown but also the mean area, mean yield of the covariance between area and yield. The change in any one of these components will lead to the change in variances of production between the two periods. Similarly the average production, E(P) can be expressed as

$$E(P) = \overline{A}\,\overline{Y} + \operatorname{cov}(AY) \text{ ----- (2)}$$

Which is affected by changes in covariance between area and yield and by change in mean area and mean yield. The decomposition analysis based on the objectives the change in variance of production [V(P)] and average production [E(P)] between the first and second periods was partitioned into constituent parts, which could be attributed separately in the mean variance and covariance of area and yield. The average production in the first period is obtained from equation (2) as

$$E(P_1) = \overline{A}_1\overline{Y}_1 + \operatorname{cov}(A_1Y_1) \text{ -----(3)}$$

And for second period

$$E(P_2) = \overline{A}_2\overline{Y}_2 + \operatorname{cov}(A_2Y_2) \text{ -----(4)}$$

Each variable in the second period can be expressed as its counter parts in the first plus the change in the variance between the two. The equation (4) can be therefore rewritten as

$$E(P_2) = (\overline{A}_1 + \Delta\overline{A})(\overline{Y}_1 + \Delta\overline{Y}) + \operatorname{cov}(A_1Y_1) + \Delta\operatorname{cov}(AY) \text{ -----(5)}$$

$$= \overline{A_1}\,\overline{Y_1} + \overline{Y_1}\Delta\overline{A} + \overline{A_1}\Delta\overline{Y} + \Delta\overline{A}\Delta\overline{Y} + Cov(A_1Y_1) + \Delta Cov(AY)$$

The change in average production was obtained by subtracting equation (3) from (5) we get

$$E(P) = E(P_2) - E(P_1) = \overline{A}_1\Delta\overline{Y} + \overline{Y}_1\Delta\overline{A} + \Delta\overline{A}\Delta\overline{Y} + \Delta\operatorname{cov}(AY) \text{ -----(6)}$$

$$= \overline{A_1}\,\overline{Y_1} + \overline{Y_1}\Delta\overline{A} + \overline{A_1}\Delta Y + \Delta\overline{A}\Delta\overline{Y} + Cov(A_1Y_1) + \Delta Cov(AY) - \overline{A_1}\,\overline{Y_1} - Cov(A_1Y_1)$$

Hence there are four sources of change in average production resulted from this equation (6). These are change in the mean yield and mean area. These are pure effects which arise even if there were no other source of change. The third term is an interaction effect, which arise from the simultaneous occurrence of changes in mean yield and mean area. The fourth term in the equation represents interaction between area and yield covariance. For easy understanding these are represented in table A below.

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Table A: The components of change in average production of major spices

Component	Symbol	Component of change
Mean yield	$\Delta \bar{Y}$	$\bar{A}\ \Delta \bar{Y}$
Mean area	$\Delta \bar{A}$	$\bar{Y}\ \Delta \bar{A}$
Interaction between changes in mean area and mean yield	$\Delta \bar{Y}\ \Delta \bar{A}$	$\Delta \bar{A}\ \ \Delta \bar{Y}$
Change in area-yield covariance	Δcov(A, Y)	Δ cov(A, Y)

Similarly the components in variance of production are given in table B for easy understanding.

Table B: The components of change in variance of production major spices

Description	Symbol	Components of change
Change in mean yield	$\Delta \bar{Y}$	$2\ \bar{A}_1 \Delta \bar{Y}$ Cov(Y_1A_1) + [$2\bar{Y}_1\Delta\bar{Y}$ +$\Delta(\bar{Y})^2$] V(A_1)
Change in mean area	$\Delta \bar{A}$	$2\bar{Y}_1\Delta\bar{A}$ Cov(Y_1A_1) + [$2\bar{A}_1\Delta\bar{A}$ +$(\Delta\bar{A})^2$] V(Y_1)
Change in yield variance	Δ V(Y)	$(\bar{A}_1)^2\Delta$V(Y)
Change in area variance	Δ V(A)	$(\bar{Y}_1)^2$ ΔV(A)
Interaction between changes in mean yield and mean area	$\Delta \bar{Y}\ \Delta \bar{A}$	$2\Delta\bar{Y}\ \Delta\bar{A}$ Cov (Y_1A_1)
Change in area yield covariance	ΔCov (Y,A)	[$2\bar{A}_1\bar{Y}_1$-2Cov(Y_1A_1)] Δcov (YA) - [Δcov(YA)]^2
Interaction between changes in mean area and mean yield variance	$\Delta\bar{A}$ ΔV(Y)	[$2\bar{A}_1\Delta\bar{A}$ +$(\Delta\bar{A})^2$]ΔV(Y)
Interaction between changes in mean yield and mean area variance	$\Delta\bar{Y}$ ΔV(A)	[$2\bar{Y}_1\Delta\bar{Y}$ +$(\Delta\bar{Y})^2$]ΔV(A)
Interaction between changes in mean area and yield, changes in area-yield covariance	$\Delta\bar{Y}\ \Delta\bar{A}$ ΔCov(YA)	[$2\bar{Y}_1\Delta\bar{A}$ +$2\bar{A}_1\Delta\bar{Y}$ +$2\Delta\bar{A}\ \Delta\bar{Y}$] ΔCov(YA)
Change in residual	ΔR	ΔV(AY) – sum of other components

Autoregressive Integrated Moving Average (ARIMA) Model

The ARIMA methodology is also called as Box-Jenkins methodology. The emphasis of these methods is not on constructing single equation or simultaneous equation models but on analyzing the probabilistic or stochastic properties of economic time series on their own under the philosophy let the data speak for themselves and allow Y_t to be explained by past or lagged values of Y itself and stochastic error terms.

THE BOX-JENKINS METHODOLOGY

Box-Jenkins methodology helps to find the values of p, d and q of an ARIMA model for a time series.This method consists of four steps [7].

Identification

The problem is to find out the appropriate values of p, d and q. One of the important tools for identification are the autocorrelation function (ACF), the partial autocorrelation function (PACF), and the resulting correlograms, which are simply the plots of ACF and PACFs against the lag length. One way of accomplishing this is to consider the ACF and PACF and the associates correlograms of a selected number of ARMA processes, such as AR(1), AR(2), MA(1), MA(2),ARMA (1,1), ARMA (2) and so on.

GARCH (Generalized Autoregressive Conditional Heteroskedasticity)

Bollerslev [4] proposed the Generalized Auto Regressive Conditional Heteroscedascity (GARCH) model in which conditional variance is also a linear function of its own lags and has the following form

$$h_t = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \ldots + \alpha_q\varepsilon_{t-q}^2 + \beta_1 h_{t-1} + \ldots + \beta_p h_{t-p}$$

$$h_t = a_0 + \sum_{i=1}^{q} a_i\varepsilon_{t-i}^2 + \sum_{j=1}^{p} b_j h_{t-j}$$

A sufficient condition for the conditional variance to be positive is

$$a_0 > 0, a_i \geq o, i = 1,2,\ldots,q; b_j \geq 0, j = 1,2,\ldots,p$$

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The GARCH (p, q) process is weakly stationary if and only if $\sum_{i=1}^{q} a_i + \sum_{j=1}^{p} b_j < 1$. The most popular GARCH model in applications is the GARCH(1,1) model. The express GARCH model in terms of ARMA model, denote $\eta_t = \varepsilon_t^2 - h_t$. Then from eq. (1).

$$\varepsilon_t^2 = a_0 + \sum_{i=1}^{Max(p,q)} \left(a_i + b_j\right) \varepsilon_{t-i}^2 + \eta_t + \sum_{j=1}^{p} b_j \eta_{t-j}$$

Thus a GARCH model can be regarded as an extension of the ARMA approach to squared series $\left\{\varepsilon_t^2\right\}$.

RESULT AND DISCUSSION

Per se performance of turmeric production in India

Table 1, gives the production performance of turmeric in India. From the table one can find that in India, since 1971 the area under turmeric is varied from 66.80 thousand hectares to 207.59 thousand hectares (2014), thereby registering growth rate of 2.37 percent per year. Positive kurtosis and positively skewed nature of Karnataka area under turmeric indicates that maximum shift in area has taken place at the early stage under study and remained almost same in later half. Andhra Pradesh registered highest average production compared to remaining major states and has registered growth rate of 2.42 percent. Platykurtic and negative skewness indicates that steady changes in turmeric area have taken place during the latter half of period under study. In case of Maharashtra with average is 7.9 thousand hectares area under turmeric increased from 6 thousand hectares (1971) to 11 thousands hectares (2014), registered growth rate of 0.22 percent. Positive value of skewness and platykurtic indicates that steady increase in area under turmeric cultivation at latter time of the study period. Odissa and Tamil Nadu with an average area of 22.79 and 18.30 thousand hectares reported a growth rate of 1.44 percent, 2.92 percent per annum respectively. Platykurtic nature followed by positive skewness in case area under turmeric in Tamil Nadu indicates marginal shift in area has taken place during early period under study and remained almost same during latter half.

The effect of expansion of area is clearly visible in the production scenario of turmeric. For whole India, from a mere 109.7 thousand tonnes of production it has reached to 1166.84 million tonnes during the period of 1971- 2014 and registering compound growth rate, simple growth rate of 4.16 percent, 10.83 percent respectively. Platykurtic and positive skewness nature of the data indicates that production increased in the initial study period and remained almost same in the latter half of the study. Likewise in the state of Karnataka, production of turmeric increased from 2 thousand tonnes (1971) to 100 thousand tonnes (2014) and registered highest growth rate of 8.50 percent (CGR) and 73.48 percent (SGR) among the major states of turmeric production. Karnataka registered an average production of 29.41 thousand tonnes. Positive nature of the skewness and kurtosis indicates that the turmeric production increased initial period and remained almost same in entire period of study. Similarly Maharashtra with average production of 10.39 thousand tonnes and has increased its production from mere 7 thousand tonnes to 16 thousand tonnes during the period under study and registered negative growth rate of -0.35% (SGR) and -0.39% (CGR). Platykurtic and positive skewness nature of the data indicates marginal shift in production has taken place during early period under study and remained almost same during latter half.

For whole India increased production of turmeric would not have been possible without a substantial increase in per hectare yield of the crop. Turmeric in India has registered an average of 3376.29 kg/ha of productivity during study period. Starting with 1642 kg per hectare (1971), it has reached to 5340 kg/ha in 2014, thereby registering a simple growth rate of 2.52% and compound growth rate of 1.75% respectively. The negative nature of kurtosis and skewness indicates that productivity increased in latter period of study and continued. State wise figures show that, Andhra Pradesh registered highest average productivity over the study of period (4398.03 kg/ha). The yield of Andhra Pradesh increased from 1944.44 kg per hectare to 7414.29 kg per hectare in the study period. Platykurtic and positive skewness indicates that steady increase in yield recorded in the initial year of the study period. The state Karnataka has average productivity of 4631.74 kg/ha and productivity increased from 1500 kg/ha to 6657.14 kg/ha register highest growth rate among major states of 7.14% (SGR) and 3.36% (CGR) respectively.

From the table 2, it is clear that the highest contribution made by change in area to average production of pepper for Andhra Pradesh is 36.06%. The yields are reduced over the period of time by change in yield and area covariance (-0.59%) in Andhra Pradesh. Change in mean area cause the highest contribution in

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change in average of production of turmeric in Karnataka, Maharashtra and Tamil Nadu. Change in mean yield is highest contributor in Odissa and India. In the state of Karnataka, Odissa, Tamil Nadu and whole India, the change in average of production is least contributed by change in yield and area covariance and in case of Maharashtra, least contribution by interaction between changes in mean area and mean yield (-6.53%).

Table 1: *Per se* performance of turmeric production in major states of India during 1971- 2014

	Andhra Pradesh	Karnataka	Maharashtra	Odissa	Tamil Nadu	India
Area ('000 ha.)						
Mean	44.06	4.93	7.90	22.79	18.30	129.84
SE	2.83	0.57	0.21	0.63	1.22	5.85
Kurtosis	-1.55	3.22	0.30	1.03	-0.23	-1.05
Skewness	-0.16	1.72	1.19	-1.43	0.69	0.01
Minimum	14.00	1.00	6.00	12.00	7.00	66.80
Maximum	73.93	16.10	11.00	28.12	38.00	207.59
SGR %	4.07	16.02	0.23	1.92	5.58	3.94
CGR %	2.42	4.97	0.22	1.44	2.92	2.37
Production ('000 tonnes)						
Mean	222.28	29.41	10.39	39.44	90.33	486.55
SE	22.97	4.07	0.38	2.80	7.16	42.71
Kurtosis	-1.41	1.32	-0.87	-1.51	-0.70	-0.75
Skewness	0.31	1.38	0.64	-0.21	0.50	0.41
Minimum	35.00	2.00	7.00	11.00	26.00	109.70
Maximum	519.00	100.00	16.00	65.80	195.00	1166.84
SGR %	14.41	73.48	-0.35	1.99	8.54	10.83
CGR %	4.74	8.50	-0.39	1.47	3.69	4.16
Productivity (kg/ha)						
Mean	4398.03	4631.74	1320.49	1738.53	4834.79	3376.29
SE	251.82	189.97	29.13	98.84	136.40	168.85
Kurtosis	-1.42	0.31	0.25	-1.46	-0.59	-1.32
Skewness	0.24	-0.66	0.59	-0.39	-0.34	-0.03
Minimum	1944.44	1500.00	958.90	636.36	2545.45	1642.22
Maximum	7414.29	6657.14	1777.78	2520.00	6552.63	5340.00
SGR %	3.70	7.14	-0.52	1.61	0.90	2.52
CGR %	2.27	3.36	-0.61	1.25	0.78	1.75

Table 2: Components of change in average of production of turmeric in major states of India

States	**Change in mean yield (%)** $\Delta\overline{Y}$	**Change in mean area (%)** $\Delta\overline{A}$	**Interaction between changes in mean area and mean yield (%)** $\Delta\overline{A}\Delta\overline{Y}$	**Change in yield and area covariance (%)** $\Delta Cov(A,Y)$
Andhra Pradesh	29.30	36.06	35.23	-0.59
Karnataka	8.04	75.76	16.68	-0.47
Maharashtra	51.83	53.49	-6.53	1.22
Odissa	71.95	17.34	14.90	-4.19
Tamil Nadu	18.06	67.81	15.89	-1.76
India	39.31	34.62	27.02	-0.95

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Table 3: Components of change in variance of production of turmeric in major states of India

State	Change in mean yield $\Delta\bar{Y}$	Change in mean area $\Delta\bar{A}$	Change in yield Variance $\Delta V(Y)$	Change in area variance $\Delta V(A)$	Interaction between changes in mean yield and mean area $\Delta\bar{A}\Delta\bar{Y}$	Change in area yield covariance $\Delta Cov(A,Y)$	Interaction between changes in mean area and yield variance $\Delta\bar{A}\Delta V(Y)$	Interaction between changes in mean yield and area variance $\Delta\bar{Y}\Delta V(A)$	Interaction between changes in mean area and yield and change in area-yield covariance $\Delta\bar{Y}\Delta\bar{A}\Delta Cov(A,Y)$	Change in residual ΔR
Andhra Pradesh	149.74	86.86	2.79	-29.91	45.11	-17.63	10.74	-87.00	-61.09	0.41
Karnataka	13.05	55.84	-3.79	49.33	4.52	-1.01	-32.10	24.11	-3.11	-6.84
Maharashtra	15.94	0.82	-7.35	72.63	-0.10	32.15	1.74	-16.66	-7.48	8.30
Odissa	-92.24	-25.42	30.75	18.14	-8.46	47.22	14.05	44.56	60.21	11.19
Tamil Nadu	330.12	707.75	-176.28	545.51	56.14	-413.95	-446.46	285.56	-548.32	-240.08
India	251.60	212.91	-36.63	-32.34	65.85	-64.03	-67.67	-70.20	-131.77	-27.72

Table 4: Test of stationarity of area, production and productivity of turmeric in India

Area ('000 ha)			
State	ADF Value	P-value	Conclusion
Andhra Pradesh	-1.45	0.79	Non Stationary
Karnataka	-1.31	0.85	Non Stationary
Maharashtra	-0.06	0.99	Non Stationary
Orissa	-2.58	0.34	Non Stationary
Tamil Nadu	-3.79	0.17	Non Stationary
India	-3.67	0.07	Non Stationary
Production ('000 tonnes)			
Andhra Pradesh	-3.00	0.18	Non Stationary
Karnataka	-1.90	0.61	Non Stationary
Maharashtra	-1.46	0.79	Non Stationary
Orissa	0.20	0.99	Non Stationary
Tamil Nadu	-5.68	0.25	Non Stationary
India	-3.78	0.32	Non Stationary
Productivity (kg per hectare)			
Andhra Pradesh	-3.52	0.05	Non Stationary
Karnataka	-2.48	0.39	Non Stationary
Maharashtra	-3.01	0.17	Non Stationary
Orissa	-2.01	0.57	Non Stationary
Tamil Nadu	-2.02	0.57	Non Stationary
India	-3.15	0.12	Non Stationary

Table 5: Best fitted ARIMA and GARCH models for area, production and productivity turmeric in India

State	Model	Model Selection Criteria								
		AIC	BIC	ME	RMSE	MAE	MPE	MAPE	MASE	R^2
Area ('000 ha)										
Andhra Pradesh	ARIMA(1,1,1)*	254.29	256.00	0.83	5.18	3.93	1.24	10.14	0.98	0.92
	GARCH (1)	261.87	270.56	1.45	7.33	3.86	3.23	10.57	1.35	0.92
Karnataka	ARIMA(1,1,2)*	124.82	126.53	0.10	1.07	0.71	-0.78	16.73	0.98	0.81
	GARCH (2)	148.61	159.04	1.34	1.45	0.94	-0.34	21.12	1.23	0.66
Maharashtra	ARIMA(1,1,1)*	86.12	89.55	-0.13	0.65	0.35	-1.95	4.40	1.11	0.75
	GARCH (1)	89.52	91.21	-0.08	0.94	0.36	-1.23	4.41	2.35	0.67
Odissa	ARIMA(1,2,1)*	172.34	175.76	0.38	1.86	1.39	1.61	6.34	1.00	0.84
	No GARCH									
Tamil Nadu	ARIMA(3,1,1)*	217.31	224.16	0.65	3.01	2.35	1.85	13.53	0.65	0.83
	No GARCH									
India	ARIMA(1,1,2)	325.19	332.04	-0.24	11.35	8.09	-0.75	6.27	0.86	0.90
	GARCH (1)*	320.74	329.43	-0.47	10.58	7.69	-0.84	5.43	0.68	0.90
Production ('000 tonnes)										
Andhra Pradesh	ARIMA(1,1,2)*	450.03	456.89	-4.58	51.72	38.21	-19.38	28.85	0.92	0.88
	GARCH (4)	453.88	467.78	-3.32	53.44	39.66	-18.24	28.60	1.35	0.87
Karnataka	ARIMA(1,1,3)*	358.71	362.13	3.11	18.00	9.73	0.27	31.39	0.95	0.58
	GARCH (1,2)	369.01	381.18	5.34	23.46	10.72	0.63	49.34	1.35	0.44
Maharashtra	ARIMA(1,1,2)*	159.92	161.63	-0.12	1.64	1.02	-2.46	10.23	0.98	0.63
	GARCH (1)	195.07	153.76	-0.04	2.35	0.99	-4.32	10.20	2.35	0.67
Odissa	ARIMA(1,1,2)*	293.83	295.55	0.48	8.40	4.91	-0.56	13.26	0.98	0.81
	No GARCH									
Tamil Nadu	ARIMA(1,1,1)*	391.29	393.00	2.02	27.56	22.50	-2.79	28.27	0.98	0.73
	GARCH (1,2)	398.70	410.86	4.35	32.46	18.48	-1.35	25.46	1.43	0.68
India	ARIMA(2,1,1)	495.36	498.78	0.00	95.70	63.89	-5.02	15.79	0.93	0.87
	GARCH (3)*	493.76	505.92	0.00	93.32	55.47	-7.33	13.97	0.75	0.89
Productivity (kg per hectare)										
Andhra Pradesh	ARIMA(1,1,1)*	665.09	666.80	98.56	777.01	509.89	1.08	11.48	0.98	0.79
	No GARCH									
Karnataka	ARIMA(1,1,2)*	663.45	666.88	153.58	742.51	545.12	2.69	12.21	0.97	0.69
	No GARCH									
Maharashtra	ARIMA(2,1,1)*	525.88	529.30	-1.91	138.64	95.74	-0.86	7.36	0.90	0.57
	GARCH (1,2)	543.95	556.12	-0.89	141.35	97.01	-0.13	7.38	1.32	0.55
Odissa	ARIMA(1,1,1)*	581.38	583.09	30.72	279.94	151.39	-0.28	10.59	0.98	0.83
	No GARCH									
Tamil Nadu	ARIMA(1,1,2)*	649.36	652.79	69.88	624.51	450.24	0.19	9.66	0.96	0.66
	No GARCH									
India	ARIMA(1,1,3)*	631.28	633.00	71.25	514.50	364.48	0.90	10.72	0.98	0.78
	No GARCH									

*Note: * indicates the best model and used further for forecasting purpose*

Table: 6 Validation and forecasting of area ,production and productivity of turmeric in India on the basis of selected best model

State	Model	2012		2013		2014		2015	2018	2020
		Observed	Predicted	Observed	Predicted	Observed	Predicted	Predicted	Predicted	Predicted
Area ('000 ha)										
Andhra Pradesh	ARIMA(1,1,1)	59	59	68	61	67	69	74	79	84
Karnataka	ARIMA(1,1,2)	16	11	16	13	16	18	21	26	29
Maharashtra	ARIMA(1,1,1)	7	7	11	9	11	13	16	19	22
Odissa	ARIMA(1,2,1)	24	25	24	29	24	31	34	38	44
Tamil Nadu	ARIMA(3,1,1)	18	18	36	31	38	28	26	22	23
India	GARCH (1)	160	171	194	174	198	177	182	187	192
Production ('000 tonnes)										
Andhra Pradesh	ARIMA(1,1,2)	485	446	423	456	451	474	485	518	540
Karnataka	ARIMA(1,1,3)	100	81	100	83	100	82	84	87	93
Maharashtra	ARIMA(1,1,2)	8	9	11	8	11	8	8	8	8
Odissa	ARIMA(1,1,2)	36	48	30	36	30	36	36	36	36
Tamil Nadu	ARIMA(1,1,1)	126	136	190	186	195	176	176	176	176
India	GARCH (3)	1167	1035	987	1091	1029	1215	1239	1312	1360
Productivity (kg per hectare)										
Andhra Pradesh	ARIMA(1,1,1)	6470	6729	6240	6572	6130	6470	6385	6256	6184
Karnataka	ARIMA(1,1,2)	6290	5992	6210	6088	6210	6088	6088	6088	6088
Maharashtra	ARIMA(2,1,1)	1250	1206	1100	1230	1175	1237	1234	1235	1235
Odissa	ARIMA(1,1,1)	2520	2396	2100	2404	2100	2452	2486	2502	2520
Tamil Nadu	ARIMA(1,1,2)	5410	5493	5320	5444	5200	5284	5357	2452	5444
India	ARIMA(1,1,3)	5340	5491	5000	5340	4960	5145	5238	5295	5340

Components of change in variance of production of turmeric in major states of India

From table 3, it is clear that the state Andhra Pradesh and whole India the variance of production is highly contributed by the change in mean yield (149.74% and 251.60% respectively) and variance of production least contributed by the interaction between changes in mean yield and area variance (-87%) in Andhra Pradesh, interaction between changes in mean area and yield and change in area-yield covariance (-131.77%) in India. In the state Karnataka the variance of production of turmeric, the major contributor are change in mean area (55.84%) and least contributor are interaction between changes in mean area and yield variance (-32.10%). Change in area variance (72.63%) highly contributor and interaction between changes in mean yield and area variance (-16.66%) least contributor of variance of production of turmeric in Maharashtra. For the state Odissa and Tamil Nadu, the highest contribution by interaction between changes in mean area and yield and change in area-yield covariance and change in mean area respectively, least contribution by change in mean yield (-92.24%) and interaction between changes in mean area and yield and change in area-yield covariance (-548.32%).

Results of stationarity test of area, production and productivity data series of turmeric in major states of India are presented in table 4. From the table one can find that ADF test for the data series of area under turmeric reject the hypothesis that data are stationarity. First or second order differencing was necessary for the series to make it stationary. After achieving stationarity, various ARIMA models are tried for each series and only the best model among the competitive models for each series is selected based on minimum value of AIC, BIC, ME, RMSE, MAE, MPE, MAPE and maximum value of R^2. On the other hand, in similar way, various GARCH models have been fitted and best GARCH model for each series is selected and presented in table 5. From table 5 it is clearly visible that, except turmeric area and production for whole India, rest ARIMA model has been better than GARCH and used for forecasting purpose. The

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selected models are also validated for accuracy for last three years and observed that the actual and predicted values are almost in range for all the states including whole India (Table 6).
The forecasted values indicate that area under turmeric would increase marginally in Andhra Pradesh, Karnataka,Maharashtra and Odissa; whereas Tamil Nadu and whole India, forecasted value marginally decreased in 2020 as compared to year 2014 value. As such are used for forecasting turmeric production up to 2020 (Table 6). From the forecasted values, it can be seen that turmeric production would increase marginally in 2020 as compared to 2014 in Andhra Pradesh, Odissa and whole India whereas Karnataka, Maharashtra, Tamil Nadu has the tendency to decrease its production capacity in future. In the state Karnataka and Maharashtra, the area has increased considerably but production shows declined forecasted value for future 2020 as compare to base year value 2014. The actual reason for this may be lack of improved varieties and technology, lack of market facilities, poor post harvest facilities and more interest to other spice crops like chilly. The forecasted figures indicate that, turmeric productivity in Andhra Pradesh, Maharashtra, Odissa, Tamil Nadu and whole India would increase to 2020 as compared to base year of 2014, whereas in Karnataka it would decrease in future as compared to 2014.

CONCLUSION

India is the largest producer, consumer and exporter of turmeric in the world. Indian turmeric is considered to be the best in the world market because of its high curcumin content. India accounts for about 80 per cent of world turmeric production and 60 per cent of world exports. In present study on the basis of using of different statistical tools some important finding cameout.Though the production of Karnataka is lower than Andhra Pradesh and Tamil Nadu, it registered maximum annual growth rate than other major states. This indicated that the farmers perceived the high profitability of turmeric production but they were not encouraged or helped by the spice producing and marketing agencies. Mean yield contributes the highest variance in turmeric production during the study under investigation. The reason for declining in area of turmeric in Tamil Nadu are Turmeric is 9 months crop compare to other crop like Maize and Soya bean (3 months).Lack of water availability during summer. Higher realization in other crops grown in same area [1]. Development of policies related to proper crop insurance and standard minimum support prices will encourage the farmers to cultivate the turmeric in Tamil Nadu. This study help for policy implication as well as to improve the productivity of turmeric in India.

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