Trend Analysis With Respect To Area, Production And Yield Of Cotton In Maharashtra

M. O. Wankhade, H. A. Bhosale

Abstract: This study relates to the trend analysis of Area under cotton, production and productivity in Maharashtra, India. Time series data for last 54 years (from 1964-65 to 2017-18) is collected. Comparative study of Growth curve model, Linear trend model and Quadratic Trend models is made and the forecasts are generated for 10 years. Accuracy measures for estimates viz. Mean square deviation (MSD), Mean absolute percent error (MAPE) and mean absolute deviation (MAD) are used for suggesting the best model. On the basis of MSD, MAPE and MAD, we observed that quadratic trend model provides more accurate estimates as compared to growth curve model and linear trend model.

Key Words: Cotton, Linear, Growth curve, quadratic trend, MAPE, MSD, MAD

Introduction:

Cotton (Gossypium spp) is the most important crop in India. Maharashtra, Gujarat, Andhra Pradesh, Telangana and Karnataka are most cotton producing states in India. The four major cotton producing countries are China, India, USA and Pakistan which accounted for approximately three quarters of world output.[5] In India, cotton plays a key role in the national economy in terms of both employment generation and foreign exchange earnings. By way of exports, foreign exchange earnings of cotton amount to about Rs. 50000 crores, which is nearly one-third of the total foreign exchange earnings of output country. It is expected to increase significantly in the coming years with the termination of quota regime in the liberalized trade scenario.[3] India is currently first in area, second in yarn production and third in raw cotton production in the world. The cotton crop is cultivated in 12.3 million hectares with a production of 29.3 million bales each of 170 Kgs, at an average of 518 kg/ha. in 2017-18.2 Among Indian cotton growing states Gujarat, Maharashtra and Madhya Pradesh, contributed near about 60 per cent of the total cotton production in India. Andhra Pradesh and Telangana is main producer of cotton in southern part on India. Gujarat, Maharashtra, Madhya Pradesh, Andhra Pradesh, Telangana, Tamil Nadu, Rajasthan, Haryana, Punjab and Karnataka accounted for more than 95 per cent cotton production in India. In Maharashtra area under cotton is 42 lakh hectares, production 85 lakh bales of cotton and yield 343.48 kg/hectare. Maharashtra contribute more than one-third of cotton area and near about one-fifth of cotton production in the country.[1,2] Maharashtra had three distinct cotton regions i.e. Vidarbha with assured rainfall, Marathwada lower rainfall than Vidarbha and rest of Maharashtra.

Methodology:

In the present study data are collected on area under cotton, production and yield (kg/hectare) from various publication and official websites of department of agriculture Maharashtra state, Epitome of agriculture in Maharashtra-part 2, Directorate of Economics and Statistics Government of India, Handbook of statistics on the Indian Economy, Cotton Advisory Board of India and The Economic Outlook For U.S. Cotton 2018. The data have been collected for the period 1964-65 to 2017-2018. Growth curve model, Linear trend model and Quadratic Trend models are compared for analysis of trend with respect to area under crop (million hectares), production (million bales) and yield (kg/hectare) in the state of Maharashtra for the period 1964-2018. Accuracy measures for estimates viz. Mean square deviation (MSD), Mean absolute percent error (MAPE) and mean absolute deviation (MAD) are used for suggesting the best fit model for given time series data. Forecasts for 10 periods are generated and residual analysis in made using MINITAB 19.

Growth curve model: $Y_t = a * b^t$

Linear trend model : $Y_t = a + b * t$

Quadratic Trend model : $Y_t = a + b * t + c * t^2$

Mean square deviation : $MSD = \frac{1}{n}\sum_{t=1}^{n}[Y_t - \hat{Y}_t]^2$

Mean absolute percent error: MAPE

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left[\left|\frac{Y_t - \hat{Y}_t}{Y_t}\right|\right] * 100$$

Mean absolute deviation (MAD)

$$MAD = \frac{1}{n}\sum_{t=1}^{n}\left|Y_t - \hat{Y}_t\right|$$

Area, production and Yield of cotton in Maharashtra

Year	Area	Production	Yield
	Lakh hectare	Lakh bales (bale= 170 kg)	kg/hectare
1964-65	28.24	12.51	80
1965-66	26.63	10.03	68
1966-67	26.11	10.75	74
1967-68	27.94	13.53	87
1968-69	27.17	13.57	88
1969-70	28.11	12.14	78
1970-71	28.12	4.82	31
1971-72	23.78	9.17	69
1972-73	25.31	10.53	75
1973-74	22.47	10.16	77
1974-75	25.02	17.17	112
1975-76	23.1	7.72	57
1976-77	21.2	8.33	67
1977-78	23.14	12.63	93
1978-79	25.09	13.17	90
1979-80	25.88	16.95	111
1980-81	26.67	12.69	81
1981-82	27.1	14.65	92
1982-83	26.48	16.09	103
1983-84	26.85	8.14	52
1984-85	26.85	14.67	95

- *M. O. Wankhade, Dept. of Statistics, G. S. Sci.,Arts & Commerce, College, Khamgaon (MS) India email: mowankhade289@gmail.com*
- *H. A. Bhosale, Dept. of Economics G. S. Sci.,Arts & Commerce, College, Khamgaon (MS) India email: bhosaleh09@rediffmail.com*

1985-86	27.53	19.89	91
1986-87	26.92	8.88	78
1987-88	25.17	14.67	96
1988-89	26.27	13.73	107
1989-90	26.35	22.11	121
1990-91	27.3	15	93
1991-92	27.27	12.48	78
1992-93	24.8	20.5	141
1993-94	27.3	25	156
1994-95	27.6	15.84	98
1995-96	30.7	28.74	159
1996-97	30.85	33	182
1997-98	31.39	21.5	116
1998-99	31.99	26.5	141
1999-2000	32.54	38	199
2000-01	30.77	18.25	101
2001-02	29.8	34.25	195
2002-03	28.01	26	158
2003-04	27.66	31	191
2004-05	28.4	52	311
2005-06	28.75	36	213
2006-07	31.07	50	274
2007-08	31.91	62	330
2008-09	31.33	62.1	336
2009-10	35.03	65.75	319
2010-11	39.42	87.75	379
2011-12	41.25	76	313.21
2012-13	41.46	81	332.13
2013-14	41.92	84	340.65
2014-15	41.9	80	324.58
2015-16	42.07	76	307.11
2016-17	38	88.5	395.92
2017-18	42.07	85	343.48

Source: Cotton Advisory Board of India

Results and Discussion:

1. Statistical measures:
Statistical measures are computed and presented in the following table.

Statistical Constants	Area (Lakh hectare)	Production Lakh bales (bale= 170 kg)	Yield (kg/hectare)
Mean	29.5566	30.7566	161.1126
Standard Error	0.7504	3.5291	14.2682
Standard Deviation	5.5145	25.9341	104.8496
Coefficient of Variation	18.6575	84.3202	65.0784

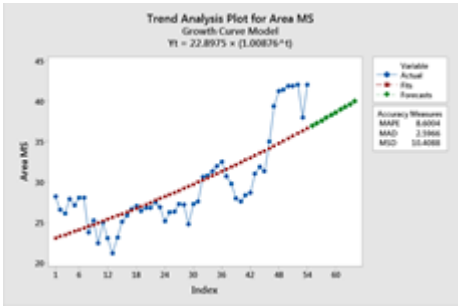
2. Trend Analysis:
Growth curve model, Linear trend model and Quadratic trend model are fitted for area under crop, production of cotton and yield of cotton in Maharashtra using the principle of least squares in MINITAB 19.

2.1 Fitted Trend Curves for Area under cotton:

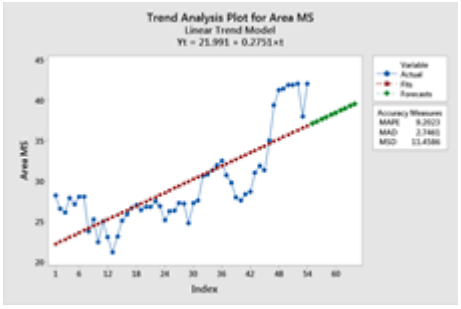
Accuracy measures	Fitted Trend equations under		
	Growth Curve Model	Linear Trend Model	Quadratic Trend Model
	Yt = 22.8975 *(1.00876^t)	Yt = 21.991 + 0.2751*t	Yt = 28.025 - 0.3714*t + 0.01176*t^2
MAPE	8.6004	9.2023	6.24397
MAD	2.5966	2.7461	1.83783
MSD	10.4088	11.4586	4.94125
Year	**Forecasts**		
2018	36.9928	37.1228	43.1575
2019	37.3169	37.3980	44.0910
2020	37.6438	37.6731	45.0480
2021	37.9735	37.9482	46.0285
2022	38.3062	38.2234	47.0325
2023	38.6417	38.4985	48.0600
2024	38.9802	38.7736	49.1110
2025	39.3217	39.0488	50.1855
2026	39.6662	39.3239	51.2836
2027	40.0136	39.5990	52.4051

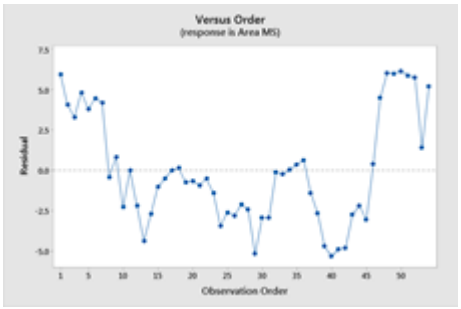
(MS-Represents Maharashtra in all figures)

a. Growth Curve model: For area under cotton.

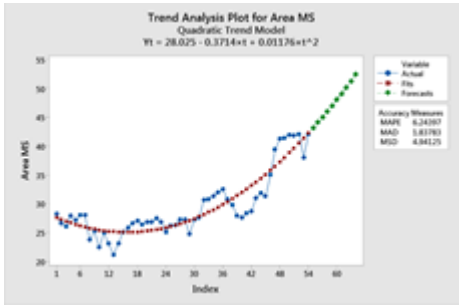


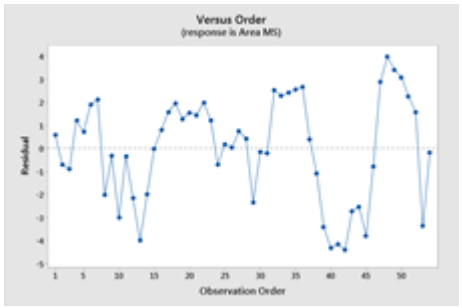
b. Linear trend model: For area under cotton



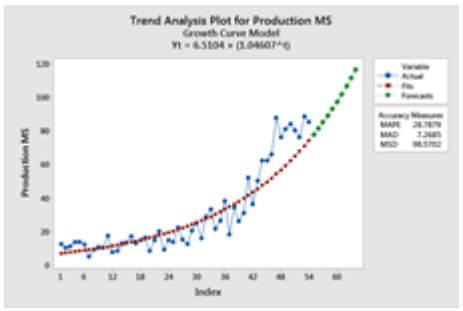


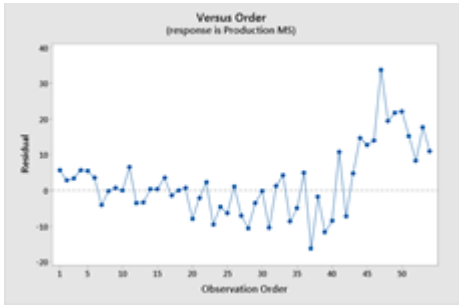
c. Quadratic Trend Model: For area under cotton



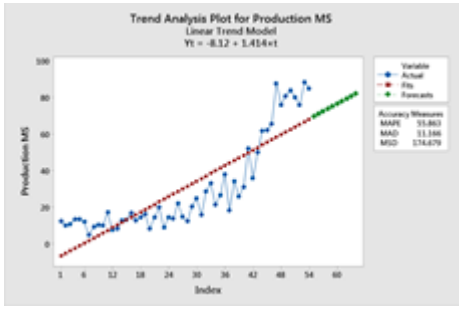


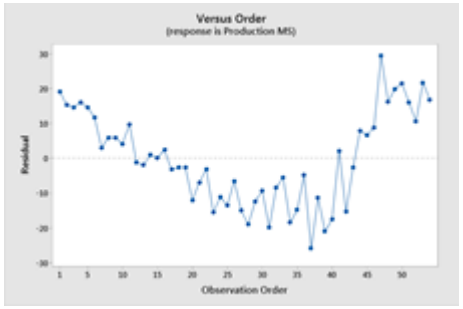
a. Growth Curve model: For Production of cotton bales



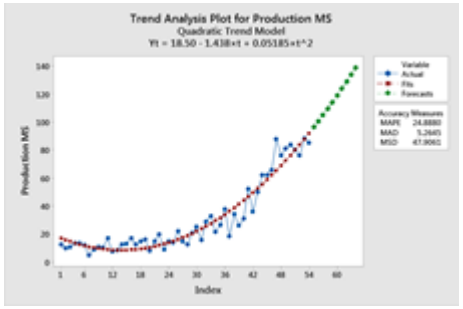


b. Linear trend model: For Production of cotton bales





c. Quadratic Trend Model: For Production of cotton bales



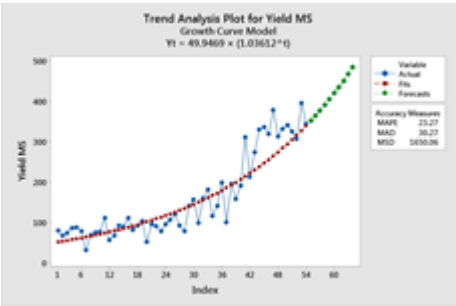
2.1 Fitted Trend Curves for Production of cotton:

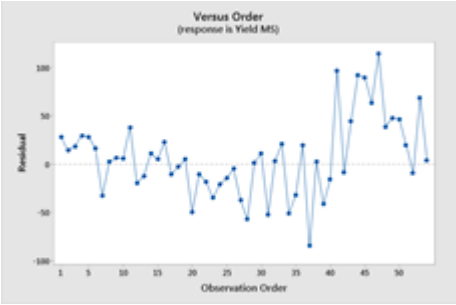
Accuracy measures	Model		
	Growth Curve Model	Linear Trend Model	Quadratic Trend Model
	Yt = 6.5104 * (1.04607^t)	Yt = -8.12 + 1.414*t	Yt = 18.50 - 1.438*t + 0.05185*t^2
MAPE	28.7879	55.863	24.8880
MAD	7.2685	11.166	5.2645
MSD	98.5702	174.679	47.9061
Year	**Forecasts**		
2018	77.529	69.6319	96.247
2019	81.101	71.0456	100.564
2020	84.837	72.4592	104.985
2021	88.746	73.8729	109.510
2022	92.834	75.2865	114.138
2023	97.111	76.7002	118.870
2024	101.585	78.1138	123.706
2025	106.265	79.5274	128.645
2026	111.161	80.9411	133.688
2027	116.282	82.3547	138.835

2.2 Fitted Trend Curves for Yield of cotton:

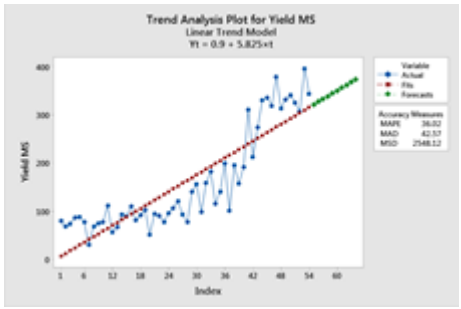
Accuracy measures	Model		
	Growth Curve Model	Linear Trend Model	Quadratic Trend Model
	Yt = 49.9469 * (1.03612^t)	Yt = 0.9 + 5.825*t	Yt = 90.4 - 3.76*t + 0.1742*t^2
MAPE	23.27	36.02	19.59
MAD	30.27	42.57	24.93
MSD	1650.06	2548.12	1116.99
Year	**Forecasts**		
2018	351.697	321.294	410.720
2019	364.402	327.119	426.300
2020	377.565	332.944	442.229
2021	391.205	338.769	458.506
2022	405.337	344.594	475.131
2023	419.980	350.418	492.105
2024	435.151	356.243	509.427
2025	450.871	362.068	527.098
2026	467.158	367.893	545.117
2027	484.034	373.718	563.485

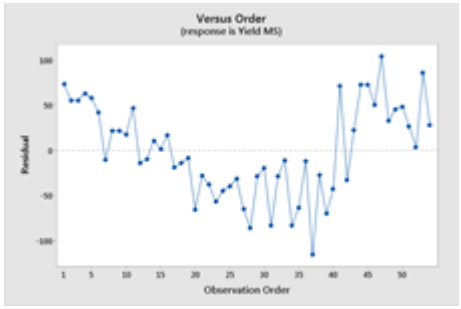
a. Growth Curve model: Yield of cotton (kg/hectare)



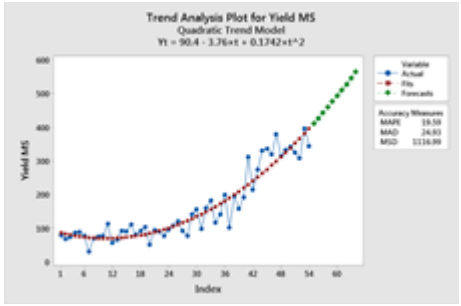


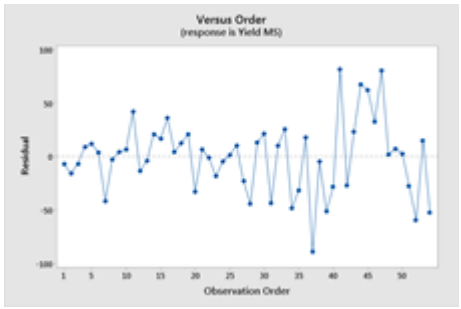
b. Linear trend model: Yield of cotton (kg/hectare)





c. Quadratic Trend Model: Yield of cotton (kg/hectare)





Conclusion:

The study reveals that an average area under cotton is found to be 29.56 lakh hectares with coefficient of variation 18.66%, Cotton production 30.76 lakh bales with coefficient of variation 84.32% and Yield 161.11 kg per hectare with coefficient of variation 65.078%. We observed that there is 18.66% variation in area under crop, 84.32% variation in production and 65.078% in yield kg/hec. of cotton. There is more variability in production of cotton bales as compared to area under crop and yield per hectare of cotton. Accuracy measures viz. MAPE, MAD and MSD reveals that quadratic trend model is the best fit as compared to growth curve and linear trend models for the data under study. Quadratic trend model showed higher forecasts values than growth curve and linear trend model. Linear trend model leads to the lower forecasts. the residuals are observed to be at lower side in quadratic trend model than

other two models under study. We conclude that quadratic trend model is the best fit model for the trends in area, production and yield of cotton in Maharashtra.

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