Trends in Area, Production and Productivity of Chickpea in Prakasam District

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ABSTRACT

This paper attempted to identify the trends of area, production and productivity of chickpea in Prakasam district of Andhra Pradesh through fitting linear and non-linear growth models. Secondary yearly data on area, production and productivity of Chickpea for a period of 39 years *i.e.* from 1976 to 2014 was used. For forecasting up to 2020 AD two years moving average model was identified as the best model for area, production and productivity of Chickpea. It was observed that there is a slight increase in area and production, whereas, productivity showed stability in growth.

Key words: *Moving average, Growth models.*

Chickpea (*Cicer arietinum*) generally known as 'Chana'/ 'Gram' or 'Bengal Gram' in India is an important leguminous food crop. India is the largest producer of chickpea with about 63% of the total area under chickpea production lying in India. Chickpea is a highly nutritious legume crop. Chickpea/ Bengal gram is widely appreciated as a health food. It is a protein rich supplement to cereal based diets, especially to the poor in developing countries, where the people are vegetarians or cannot afford animal protein. The main objective of the present study is to study the trends and forecast the area, production and productivity of Chickpea by 2020 AD using the best fitted model based on the selection criterion.

Andhra Pradesh is categorized among the states which show high growth rate of chickpea production in India. Chickpea has been taken up in drought prone districts like Kurnool and Prakasam of Andhra Pradesh, which were the top producers of chickpea. Chickpea is emerging as a cash crop in black cotton soils of Andhra Pradesh replacing different crops like cotton, sorghum, bajra, sugarcane, groundnut and tobacco. Deshmukh (2011), Sudha *et al.*(2013), Nireesha *et al.*(2016), Rao and Srinivasulu (2006), Rahman and Imam(2008) studied the growth pattern in different crops and has done the forecasting by fitting the best fitted model.

MATERIAL AND METHODS

The study was confined only to the area, production and productivity of the Chickpea crop in Prakasam district, Andhra Pradesh. The data was collected on area, production and productivity of Chickpea for a period of 39 years *i.e.*, 1976 to 2014 from the Chief Planning Office, Ongole.

In this paper an attempt has been made for forecasting of area, production and productivity of Chickpea in Prakasam district of Andhra Pradesh by using Linear, Non-linear growth models. Linear, Quadratic, Cubic, Exponential, Compound, Logarithmic, Inverse, Power, S-curve, Growth functions were fitted by using SPSS 20.0 version software. Identified the best fitted model based on the model selection criteria. Among fitted models which were having highest R^2, least MAPE, MAE and RMSE values model was selected. Forecasting the area, production and productivity of Chickpea in Prakasam district up to 2020 AD was done based on the best model identified.

Coefficient of Determination (R^2)

R^2 is a statistic that will give some information about the goodness of fit of a model. In regression, the R^2 *i.e.,* coefficient of determination will explains the variability of the model .

$$R^2 = \frac{\sum_{i=1}^{n}(y_i-\hat{y}_i)}{\sum_{i=1}^{n}(y_i-\bar{y})^2} \quad \frac{Regression\ sum\ of\ squares}{Total\ sum\ of\ squares}$$

Residual mean square error (RMSE)

The Residual Mean Sum of Square is defined as

$$RMSE = \sqrt{\frac{\sum(\hat{y}_i - y_i)^2}{n-k}}$$

The model with minimum RMSE is assumed to describe the data series adequately.

Mean absolute error (MAE)

In statistics, the mean absolute error (MAE) is a quantity used to measure how close forecasts or predictions are to the eventual outcomes. The mean absolute error is given by

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|\varepsilon_i|$$

Mean Absolute Percent Error (MAPE)

It is a measure of accuracy of a method for constructing fitted time series values in statistics, specifically in trend estimation. It usually expresses accuracy as a percentage, and is defined by the formula:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\frac{|\varepsilon_i|}{y_i}x\ 100$$

RESULTS AND DISCUSSION

Area of chickpea showed a stationary growth till 1998 and then an increase from 2000 onwards during the study period. The 2 year moving average was with highest significant R^2 (0.98) and least MAPE (13.99), MAE (3413.37) and RMSE (5844.56) values at 1% level of significance. The linear, quadratic, cubic, compound, power and exponential models were significant but those are not the best fitted models for forecasting. The results obtained by fitting all the growth models were presented in table 1.

Table 1.Growth models of Chickpea Area in Prakasam district of Andhra Pradesh

S.NO.	Model	a	b	c	d	R^2	MAPE	MAE	RMSE
1	Linear	-26480	2967	-	-	0.78**	512.28	18021.58	20719.58
2	Logarithmic	-51130	30720	-	-	0.46	807.54	25670.48	29275.06
3	Inverse	41890	-82740	-	-	0.13	962.94	32877.75	36945.32
4	Quadratic	-3206	-438.59	85.14	-	0.79**	187.05	13133.24	18301.61
5	Cubic	27200	-9022	614.86	-8.83	0.85**	312.16	12923.34	15358.37
6	Compound	221.64	1.194	-	-	0.74**	53.53	19053.57	20259.09
7	Power	26.675	2.07	-	-	0.59**	91.20	18492.39	25391.68
8	S	9.607	-6.071	-	-	0.20	188.35	28532.27	35402.08
9	Growth	5.401	0.177	-	-	0.74	53.22	18929.38	20259.09
10	Exponential	221.64	0.177	-	-	0.74**	53.22	18929.97	20259.09
11	**2 year Moving average**	-	-	-	-	**0.98****	**13.99**	**3413.37**	**5844.56**

** Significant at 1% level

Table 2. Growth models of Chickpea Production in Prakasam district, Andhra Pradesh

S.NO.	MODEL	A	b	c	d	R^2	MAPE	MAE	RMSE
1	Linear	-48560	5177	-	-	0.71^{**}	2035	28976.8	37141.9
2	Logarithmic	-90410	53170	-	-	0.44	6322	65092.8	51838.1
3	Inverse	70460	-142000	-	-	0.13	9301	56587.2	64739.9
4	Quadratic	-4177	-1318	162.37	-	0.78^{**}	562.7	21807.6	32314.4
5	Cubic	44410	-15030	1009	-14.1	0.83^{**}	3157	21116.6	28198.2
6	Compound	121.21	1.233	-	-	0.87^{**}	182.2	37208.7	25240.3
7	Power	10.778	2.419	-	-	0.67^{*}	463.1	36279	39516.3
8	S	9.798	-7.396	-	-	0.25	1309	50962.1	59857.5
9	Growth	4.798	0.21	-	-	0.87^{**}	183.5	38628	25240.3
10	Exponential	121.21	0.21	-	-	0.87^{**}	183.5	38600.8	25240.3
11	**2 year Moving average**	-	-	-	-	$\mathbf{0.96^{**}}$	**19.3**	**8401.2**	**4565.1**

** Significant at 1% level   * Significant at 5% level

Table 3. Growth models of Chickpea Productivity in Prakasam district of Andhra Pradesh

S.NO.	MODEL	a	b	c	d	R^2	MAPE	MAE	RMSE
1	Linear	184.47	46.713	-	-	0.74^{**}	25.96	223.22	313.07
2	Logarithmic	-358.98	540.46	-	-	0.58	44.86	332.81	314.06
3	Inverse	1301	-1674	-	-	0.22	63.85	487.19	313.07
4	Quadratic	173.83	48.269	-0.039	-	0.74^{**}	26.22	223.66	313.07
5	Cubic	552.65	-58.667	6.561	-0.11	0.78^{**}	23.29	223.69	313.07
6	Compound	365.33	1.049	-	-	0.78^{**}	21.06	233.63	351.06
7	Power	197.09	0.573	-	-	0.66^{**}	29.42	271.21	361.11
8	S	7.056	-1.893	-	-	0.29	50.01	229.61	347.91
9	Growth	5.901	0.047	-	-	0.78^{**}	20.44	227.31	294.03
10	Exponential	365.33	0.047	-	-	0.78^{**}	20.44	227.29	294.03
11	**2 Years moving Average**	-	-	-	-	$\mathbf{0.86^{**}}$	**14.28**	**148.42**	**232.39**

** Significant at 1% level

Table.4 Projections of Area, Production and Productivity of Chickpea in Prakasam district of Andhra Pradesh

year	Area('000 ha)	Production('000 tonnes)	Productivity(kg ha^{-1})
2015	55429	105678	1903
2016	57768	110583	1910
2017	56598	108130	1907
2018	57183	109357	1908
2019	56891	108744	1907
2020	57037	109051	1908

The average production of Chickpea during the study period (1976-2014) was 56252.71 thousand tones. The production of Chickpea crop in Prakasam district, Andhra Pradesh exhibited an increasing growth pattern during the study period of 1976-2014. Various linear and non linear models were fitted like linear, quadratic, cubic, compound, power, growth and exponential model. Among these models, moving average model having highest significant R^2 (0.96) and the least MAPE (19.3), MAE (8401) and RMSE (14565.08) values at 1% level of significance. The results obtained by fitting all the ten growth models were presented in table 2.

The average yield of Chickpea in Prakasam district of Andhra Pradesh during the study period is 1118.718 kg ha^{-1} showing increasing trend from 1976-1994 and in the later years of the study period it showed irregular growth. Among these models, two year Moving Average is with highest significant R^2 (0.86) and the least MAPE (14.28), MAE (148.42) and RMSE (232.39) values at 1% level of significance. The results obtained by fitting all the ten growth models are presented in table 3.

Based on the best identified model (two year moving average) the Chickpea area, production and productivity is forecasted and tabulated in the Table 4 and Fig.1, 2 and 3 respectively. It is observed from the table the forecasted values of Chickpea area and production showed an increasing trend and later stability is observed during 2020 AD. Whereas, the forecasted productivity values of Chickpea showed a stable growth.
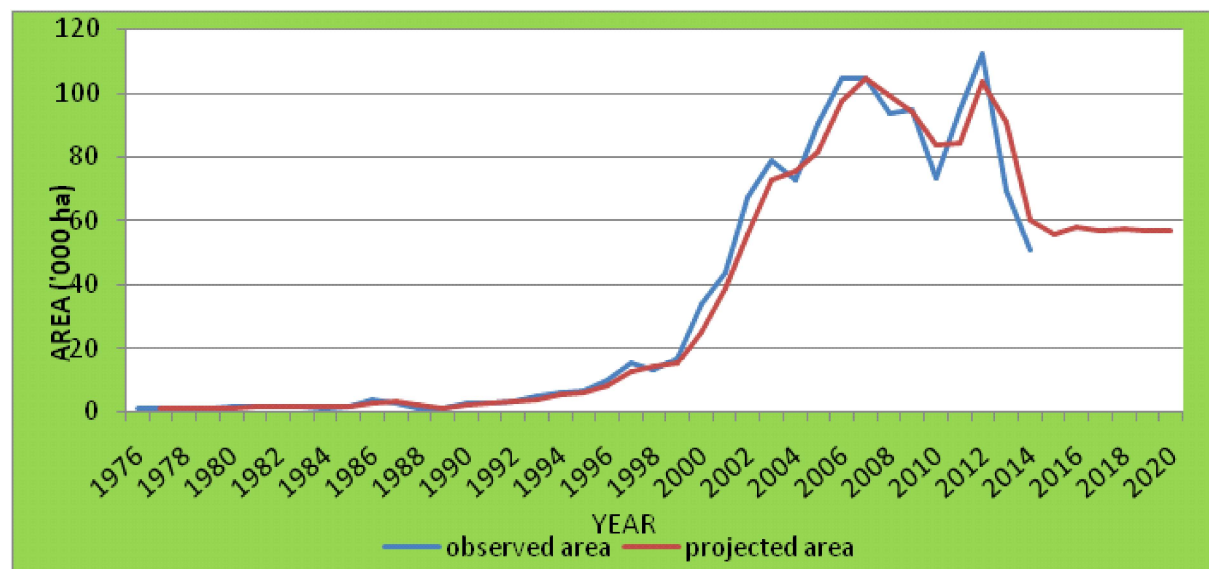

Fig.1. Observed and projected trends of chickpea production in Prakasam district of Andhra Pradesh
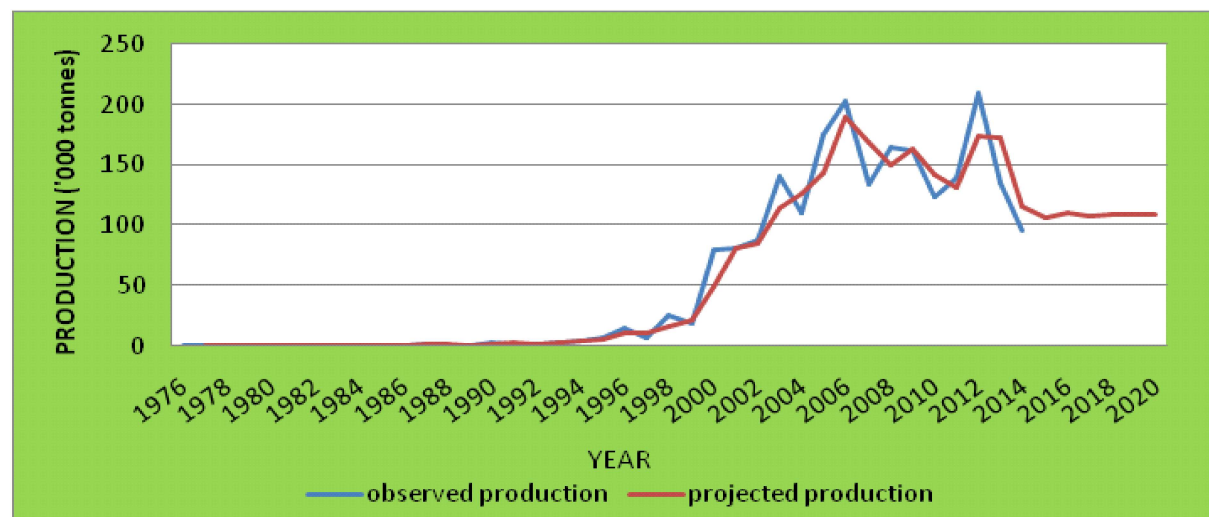

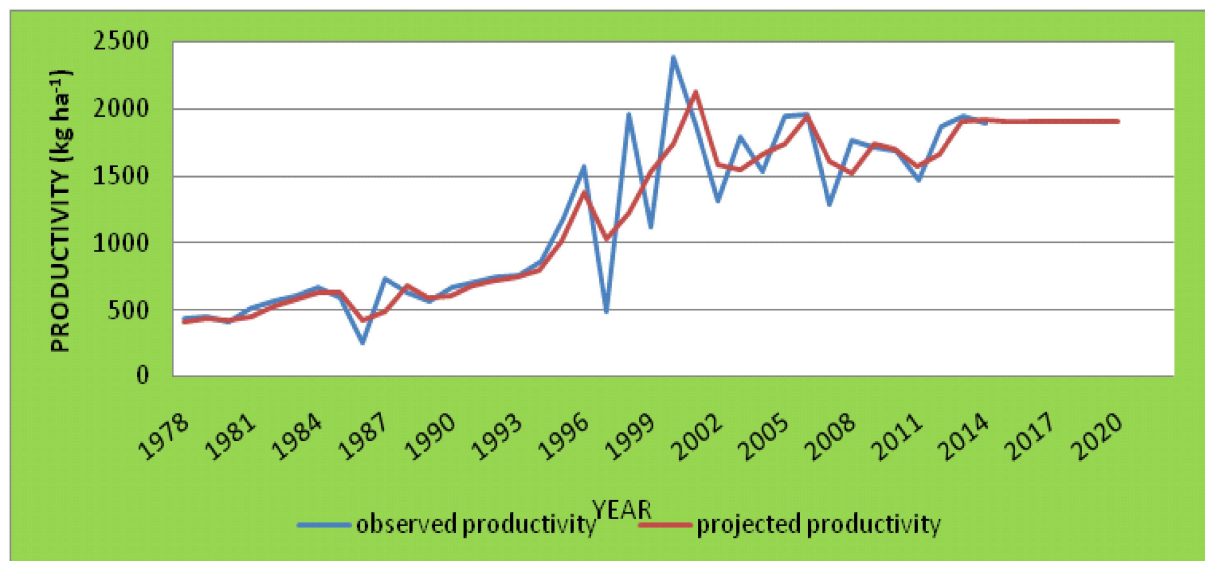Fig 2.Observed and projected trends of chickpea production in Prakasam district of Andhra Pradesh

Fig 3.Observed and projected trends of chickpea productivity in Prakasam district of Andhra Pradesh

CONCLUSION

Various growths models like linear, cubic, quadratic, exponential, power and growth models were fitted to study the trend in area, production and productivity of chickpea. But the 2 years moving average model was identified as the best model based on enter, hence forecast was done upto 2020. Which revealed that area is in increasing trend and reached to 57037 thousand hectares in Prakasam district of Andhra Pradesh. The increased area will be influencing to gain the production from 105678 to 109051 thousand tones. But the productivity remains constant in Prakasam district of Andhra Pradesh.

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