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RESEARCH PAPER

Trend analysis and future projections in maize crop in three disrticts of Northern Telangana Zone

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Abstract : A study on "growth rates, growth models and future projections of maize crop in three districts of Northern Telangana Zone " has been undertaken to estimate the growth rates of maize crop in three districts of Northern Telangana Zone and fitted the adequate trend equation for the future projections by 2020 AD. Attempts have been made to examine the trends and forecasting in area, production and productivity of maize crop in three districts of Northern Telangana Zone. Linear and compound growth rates were calculated for this purpose. Ten growth models were fitted to the area, production and productivity of maize crop and best- fitted model for future projection was chosen based upon least residual mean square (RMS) and significant Adj R^2. Besides, the important assumption of randomness of residuals was tested using one sample run test. The reference period of study was from 1979-80 to 2012-13 and it was carried out in three districts of Northern Telangana Zone.

Key Words : Rice, Energy Input, Energy output, Specific energy

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INTRODUCTION

Maize is one of the important coarse cereal crops grown in different agro-climatic conditions of India. Maize ranks third next to wheat and rice in the world with respect to area, while its productivity surpasses all other cereal crops. Maize is grown in 70 countries of the world. The major maize growing countries are USA, China, Brazil, Mexico, Indonesia, India, France and Argentina. In some parts of the world, maize is used as food grain for human consumption. It is being used for manufacturing industrial products like starch, syrup, alcohol, acetic and lactic acids, glucose, paper, rayon, plastic, textile, adhesive, dyes, synthetic materials, rubber etc. In USA more than 90 per cent of the people use maize oil for consumption purpose and around 25 per cent of crop land area is occupied by maize. It is also used more in bakery products. In addition it is used as an important feed and fodder for animals. Nearly, 500 products of maize have been listed in USA. But, in India only 3 per cent of the total maize produce is utilized by

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industries. Maize is a rich source of starch (60-80 %), proteins (8-12 %), fat (3-5 %) and minerals (1-2 %).

India is at 6th position in maize production and 15th position in its productivity in the World. In India maize is grown all over the country. In India the major maize growing states that contributes more than 80 per cent of the total maize production are Karnataka (16.5%), Madhya Pradesh (5.7%), Maharashtra (9.1%), Rajasthan (9.9 %), Bihar (8.9 %), Uttar Pradesh (6.1 %), Telangana (4.4 %), Gujarat (4.39 %) and Tamil Nadu (4.03 %).

Maize crop is mostly grown in Telangana region of the Andhra Pradesh state. The districts of Medak, Mahaboobnagar, Karimnagar, Nizamabad, Guntur and Warangal are predominantly growing this crop which accounted for 66.29 per cent of the total area under the crop in the state during 2012-2013. Medak and Mahabubnagar districts alone accounted for 28.56 per cent of the Andhra Pradesh state. Area, production and productivity of maize in Telangana state indicate an increasing trend over a period. This increase was found to be more pronounced after the year 2000 which can be attributed to development and release of more number of high yielding private hybrids suitable for the regions. Area, production and productivity of maize in Telangana state were 6.6 lakh hectares, 29.40 lakh tonnes and 4440 kg/ha, respectively in 2012-13. (*www.indianstat.com*).

Telangana was a part of Andhra Pradesh till 1 June 2014. It has become separate state on 2 June 2014. The Telangana state attained significant acceleration in agricultural growth in the first phase of green revolution (decade of 70's). The second phase of green revolution (decade of 80's) maintained the growth rate which was attained in the first phase. Growth models are useful in drawing inferences like the exact relationship between time and growth, the rate of growth at each point of time, the turning points in the growth, growth rates are considered as the best indices of growth. Pandey (2004) calculated the area, production, productivity and exports of vegetables in India in the 1990s and also the demand projections for vegetables upto the year, 2021. He identified constraints in vegetable production and marketing and also the thrust areas for research and policy reforms. He also discussed the research, policy and government interventions in support of the Indian vegetable sector. Sharma *et al.* (2000) made an attempt to fit non-linear regression options for estimating the parameters of all the selected models, *i.e.*, logistic, Gompertz and monomolecular models. The information about the cultivation of rapeseed-mustard group of crops was collected for 30 years with respect to area and production. The logistic model was found to be unrealistic for knowing the ongoing growth of area and production. The Gompertz model was observed to be the most suitable with respect to the production as indicated by the values of co-efficient of determination of 66 and 6.9 per cent of forecast error, respectively and 0.4 per cent growth rate in production. Mathur (2005) computed the compound growth rates of area, production and productivity of rice, during the high yielding variety period (1966-67 to 2000-01) in India by the least square technique of fitting of exponential function $y=a\,b^t$. Aparna *et al.* (2008) examined the trend in growth rates of major vegetables in Visakhapatnam district with the help of compound growth rates. Kiran (2001) classified the districts of AP on basis of crop potential corresponding to the periods of technological innovations. To account for this technological effect, clustering was obtained separately for the Period-1 (1966-67 to 1979-800), Period-2 (1980-81 to 1998-99) and Period-3(1996-67 to 1998-99). The clusters, revealed that the level of crop yields under the two periods were entirely different *i.e.*, the level of crop yield in Period-2 was considerably greater than in the Period-1. The results revealed that the districts of Coastal Andhra had relatively high yield potential in respect of paddy, cotton and chillies; whereas in case of red gram, the districts of Telangana and Rayalaseema had relatively high yield potential for red gram.

The present study is based on 34 years of data *i.e.*, from 1979-80 to 2012-13 of maize crop in three districts of Northern Telangana Zone. The linear growth rate (LGR) and compound growth rate (CGR) for the crop characteristics *i.e.*, area, production and productivity of maize crop in three districts of Northern Telangana Zone are estimated by fitting the following functions, the analysis of the data has been carried out by using data on area production and productivity obtained from web site: *www.indian stat.com.*

MATERIAL AND METHODS

Methodology for the estimation of growth rates:

The study was based on 34 years of data *i.e.*, from 1979-80 to 2012-13. Keeping the objectives in view, linear growth rate (LGR) and compound growth rate (CGR) for the crop characteristics *i.e.*, area, production and productivity of major crops in three districts of Northern Telangana Zone *i.e.*, Adilabad, Karimnagar and Nizamabad were estimated by fitting the following functions.

Methodology for fitting the trend equations:

The trend equations were fitted by using different growth models. Growth models are nothing but the models that describe the behaviour of a variable overtime. The growth models taken under consideration here are as follows.

Linear function:

A linear model is one in which all the parameters appear linearly.

The mathematical eq. is given by

$$Y_t = a + bt$$

where,

Y_t is the dependent variable *i.e.*, area, production and productivity

t is the independent variable, time in years

a and b are the constants

The constants 'a' and 'b' are estimated by applying the ordinary leasts square approach.

Logarithmic function:

This model shows very rapid growth, followed by slower growth.

The mathematical eq. is given by:

$$Y_t = a + b \ln (t)$$

where,

Y_t is the dependent variable *i.e.*, area, production and productivity

t is the time in years, independent variable

'a' and 'b' are constants

The constants 'a' and 'b' are estimated by applying the ordinary least squares approach.

Inverse function:

Inverse curve shows a decreasing growth.

Inverse fit is given by the eq.

$$Y_t = a + b/t$$

where,

Y_t is the dependent variable *i.e.*, area, production and productivity

t is the independent variable, time

'a' and 'b' are parameters

The parameters can be estimated by the method of ordinary least squares (OLS).

Quadratic function:

This function is useful when there is a peak or a trough in the data of past periods.

Quadratic fit is given by the eq.

$$Y_t = a + bt + ct^2$$

where,

Y_t is the dependent variable *i.e.*, area, production and productivity

t is the independent variable, time in years

a, b and c are constants

The constants can be calculated by applying the method of ordinary least squares approach.

Cubic function:

This function is useful when there is or has been, two peaks or two troughs in the data of past periods.

Cubic fit or third degree curve is given by the eq :

$$Y_t = a + bt + ct^2 + dt^3$$

where,

Y_t is the dependent variable *i.e.*, area, production and productivity

t is the independent variable, time in years

a, b, c and d are parameters

The parameters are calculated by ordinary least squares technique.

Compound function:

This function is useful when it is known that there is or has been, increasing growth or decline in past periods

Compound fit is given by

$$Y_t = ab^t$$

or $\ln Y_t = \ln a + t \ln b$

where,

Y_t is the dependent variable, area, production and productivity

t is the independent variable, time in years

a and b are parameters or constants

The constants can be obtained by using ordinary least squares technique.

S-curve:

S-curve fit is given by

$$Y_t = \text{Exp}(a+b/t)$$

or $\ln Y_t = a + b/t$

where,

Y_t is the dependent variable, area, production and productivity.

t is the independent variable, time in years

a and b are parameters or constants

Ordinary least squares (OLS) method can be applied to estimate the parameters of the model.

Growth function:

The fit is given by

$Y_t = Exp\ (a + bt)$

or ln $Y_t = a + bt$

where,

Y_t is the dependent variable, area, production and productivity

t is the independent variable, time in years

a and b are parameters or constants

The constants are obtained by ordinary least squares technique.

Power function:

The fit is given by the eq.

$Y_t = at^b$

or ln $Y_t = \ln a + b \ln(t)$

where,

Y_t is the dependent variable, area, production and productivity

t is the independent variable, time in years

a and b are parameters or constants

The constants are calculated by ordinary least squares technique.

The fit is similar to exponential fit, but produces a forecast curve that increases or decreases at different rate.

Exponential fit:

If, when the values of t are arranged in an arithmetic series, the corresponding values of y form a geometric series, the relation is of the exponential type.

The function of this type can be given by

$Y_t = a\ Exp\ (bt)$

or ln $Y_t = \ln a + (bt)$

where,

Y_t is dependent variable *i.e.,* area, production and productivity

t is independent variable, time in years

a and b are constants

The constants are calculated by ordinary least squares technique

Methodology for the estimation of future projections:

The future projections of area, production and productivity of major crops in three districts of Northern Telangana Zone upto 2020 AD were estimated upon the best fitted growth model used for fitting the trend equations.

Methodology for the best fitted model:

The choice of the trend equation amongst the available alternatives is very crucial. Many researchers use co-efficient of multiple determination, R^2 or adjusted R^2 $(\overline{R}^2)$ as the criterion of model selection.

$$R^2 = \frac{\text{Explained variation}}{\text{Total variation}} = \frac{\sum_{i=1}^{n}(\tilde{Y}_i - Y)^2}{\sum_{i=1}^{n}(Y_i - \overline{Y})^2}$$

$$\text{Adj}R^2 = (\overline{R}^2) = R^2 - \left[\frac{K-1}{N-K}\right](1 - R^2)$$

where,

K is the number of constants in the equation

N is the total number of observations

It was observed that R^2 is not enough to examine goodness of fit of a model (Reddy, 1978). So in addition to adj R^2, the residual mean square (RMS) which will also measure the accuracy in forecasting is the best criterion to choose a model from among the alternatives.

$$\text{Residual mean square} = \frac{\sum(yi - \hat{y}_i)^2}{\text{Residual degrees of freedom}}$$

In the present study, the model with least residual mean square (RMS) and significant adj R^2 was considered to be the best fitted model.

Before choosing a model, one should be certain that the disturbance term satisfies all the conditions of randomness, non-autocorrelation, homoscedasticity and normality. In the present study, an attempt has been made to verify the most important assumption of randomness of residuals.

Test for randomness of residuals:

Non-parametric one sample run test can be used to test the randomness of residuals. A run is defined as a succession of identical symbols in which the individual scores or observations originally were obtained. For example, suppose a series of binary events occurred in this order:

++++ - - + - - - ++ - + -

This sample of scores begins with a run of four pluses. A run of two minuses follows, then comes another run of one plus and then a run of three minuses and so on. The total runs in the above example are 8.

If very few runs occur, a time trend or some bunching owing to lack of independence is suggested and if many runs occur, systematic short period cyclical fluctuations seem to be influencing the scores.

Let 'n_1', be the number of elements of one kind and 'n_2' be the number of elements of the other kind in a sequence of $N = n_1 + n_2$ binary events. For small samples *i.e.*, both n_1 and n_2 are equal to or less than 20 if the number of runs r fall between the critical values, we accept the H_0 (Null hypothesis) that the sequence of binary events is random otherwise, we reject the H_0.

For large samples *i.e.,* if either n_1 or n_2 is larger than 20, a good approximation to the sampling distribution of r (runs) is the normal distribution, with

$$\text{Mean} = \mu_r = \frac{2n_1n_2}{N} + 1$$

$$\text{Standard deviation} = \sigma_r = \sqrt{\frac{2n_1n_2(2n_1n_2 - n_1 - n_2)}{(n_1+n_2)^2(n_1+n_2-1)}}$$

Then, H_0 may be tested by $Z = \frac{r - \mu_r}{\sigma_r}$

The significance of any observed value of Z computed from the above formula may be determined by reference to the standard normal distribution table.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Adilabad:

The average area under maize during the study period (1979-80 to 2012-13) was 24.8 thousand hectares. The co-efficient of variation recorded for the study period was 14.93 per cent and the linear and compound growth rates recorded during the study period were 0.12 and 0 per cent per annum, respectively. The area of maize in Adilabad exhibited a positive trend and it was found not significant of compound growth rate and linear growth rate. The average production of maize during the study period (1979-80 to 2012-13) was 56.38 thousand tones with a co-efficient of variation of 53.58 per cent. The linear growth rate and compound growth rate recorded for the study period were 4.1 and 5 per cent per annum, respectively. The production of maize in Adilabad exhibited a positive trend and has been increasing significantly during the study period and the increase was significant at 1 per cent level of significance in the linear

Table 1: Growth rates in area, production and productivity of maize crop in Adilabad

Adilabad (%)	Area	Production	Productivity
Linear	0.12	4.1**	4.3**
Compound	0	5**	4.9**
C.V.	14.93	53.58	49.16

** indicate significance of value at P=0.01

Table 2 : Growth models of area, production and productivity of maize crop in Adilabad

Model	Linear	Logarithmic	Inverse	Quadratic	Cubic	Compound	Power	S-curve	Growth	Exponential
					Area					
AdjR^2	-0.025	0.006	0.001	0.325*	0.649*	-0.031	-0.012	-0.009	-0.031	-0.031
RMS	14.154	13.718	13.789	4.849	9.318	13.919791	13.4501259	13.9129	13.44	13.91979109
Runs	5	8	6	4	6	4	8	5	5	5
					Production					
AdjR^2	0.579*	0.478*	0.171*	0.6*	0.774*	0.642*	0.528*	0.192*	0.642*	0.642*
RMS	384.103	476.07	755.47	365.08	485.4	206.289	750.380074	486.645	424.508	486.6402494
Runs	8	6	5	8	16	6	5	6	4	6
					Productivity					
AdjR^2	0.77*	0.545*	0.172*	0.765*	0.847*	0.75*	0.543*	0.174*	0.75*	0.75*
RMS	266967	527364	960330	272042	177868	297348.2	947002.01	297688	418042	297643.2286
Runs	8	7	3	8	11	10	3	10	7	10

* indicate significance of value at P=0.05

growth rate and compound growth rate.

The future projections of area, production and productivity of maize in Adilabad region by 2020 AD were calculated and the results were presented in the Table 3. Area under maize in Adilabad region was projected by using cubic function which was found to be best for this purpose as it had significant Adj R^2 and also fulfilled the assumption of randomness of residuals. The area under maize projected by quadratic function by 2020 AD would be 14.11 thousand hectares which as in decreasing trend. Regarding the production of maize, compound function was found to be the best model for future projections by 2020 AD as it has the significant Adj R^2 and also satisfied the assumption of randomness of residuals. The projected production would be decreasing at 114.50 thousand tonnes by 2020 AD. Productivity of maize was projected by using cubic function which has lest RMS, significant Adj R^2 and also has showed significant runs. The future projection for productivity of maize also is in decreasing trend and it would be 1542 kg/ha by 2020.AD.

Karimnagar:

The average area under maize during the study period (1979-80 to 2012-13) was 99.8 thousand hectares. The co-efficient of variation recorded for the study period was 23.12 per cent and the linear and compound growth rates recorded during the study period were 1.3 and 1.2 per cent per annum, respectively. The area of maize in Karimnagar exhibited a positive trend and it was found not significant of compound growth rate and linear growth rate. The average production of maize during the study period (1979-80 to 2012-13) was 336 thousand tones with a co-efficient of variation of 50.53 per cent. The linear growth rate and compound growth rate recorded for the study period were 3.7 and 3.8 per cent per annum, respectively. The production of maize in Karimnagar exhibited a positive trend and has been increasing significantly during the study period and the increase was significant at 1 per cent level of significance in the linear growth rate and compound growth rate.

The future projections of area, production and productivity of maize in Karimnagar region by 2020 AD were calculated and the results were presented in the Table 5. Area under maize in Karimnagar region was projected by using cubic function which was found to be best for this purpose as it had significant Adj R^2 and also fulfilled the assumption of randomness of residuals. The area under maize projected by cubic function by 2020 AD would be increasing trend 72 thousand hectares. Regarding the production of maize, cubic function was found to be the best model for future projections by 2020 AD as it has the significant Adj R^2 and also satisfied the assumption of randomness of residuals. The projected production would be decreasing increasing at 482.15 thousand tonnes by 2020 AD. Productivity of maize was projected by using S-curve function which has lest RMS, significant Adj R^2 and also has showed significant runs. The future projection for productivity of maize also is in increasing trend and it would be 3429 kg/ha by 2020.AD.

Nizamabad:

The average area under maize during the study period (1979-80 to 2012-13) was 61 thousand hectares.

Table 3: Future projections of area, production and productivity of maize crop in Adilabad

Year	Area ('000'ha)	Production ('000'tonn)	Productivity(kg/ha)
2013-14	19.44	112.9	3036.3
2014-15	18.52	118.6	2827.9
2015-16	17.54	124.5	2575.4
2016-17	16.21	121.40	2276.4
2017-18	16.02	119.25	1928.4
2018-19	15.06	117.45	1529.0
2019-20	14.11	114.50	1542.0

Table 4: Growth rates in area, production and productivity of maize crop in Karimnagar

Karimnagar (%)	Area	Production	Productivity
Linear	1.33	3.7**	2.4*
Compound	1.2	3.8**	2.4*
C.V.	23.12	50.53	29.97

* and ** indicate significance of values at P=0.05 and 0.01, respectively

The co-efficient of variation recorded for the study period was 16.52 per cent and the linear and compound growth rates recorded during the study period were 0.43 and 0.3 per cent per annum, respectively. The area of maize in Nizamabad exhibited a positive trend and it was found not significant of compound growth rate and linear growth rate. The average production of maize during the study period (1979-80 to 2012-13) was 193 thousand tones with a co-efficient of variation of 48.7 per cent. The linear growth rate and compound growth rate recorded for the study period were 3.7 and 3.4 per cent per annum, respectively. The production of maize in Nizamabad exhibited a positive trend and has been increasing significantly during the study period and the increase was significant at 1 per cent level of significance in the linear growth rate and compound growth rate. Regarding the productivity in Nizamabad, the average yield of maize during the study period (1979-80 to 2012-13) was 3063 kg/ha, with the co-efficient of variation of 38.35 per cent. The linear and compound growth rates during the study period were 3 and 3.2 per cent, respectively. The productivity of maize also had exhibited a positive trend during the study period in Nizamabad and was significant at 5 per cent level of significance at linear growth rates and compound growth rate growth rates of area, production and productivity of the maize crop for the study period (1979-80 to 2012-13) in Nizamabad were shown in the Table 9. As a whole, the growth rates of production were higher than growth rates of area and productivity.

The future projections of area, production and productivity of maize in Nizamabad region by 2020 AD were calculated and the results were presented in the Table 9. Area under maize in Nizamabad region was projected by using cubic function which was found to be best for this purpose as it had significant Adj R^2 and also fulfilled the assumption of randomness of residuals. The area under maize projected by cubic function by 2020 AD would be 143 thousand hectares which as in positive trend. Regarding the production of maize, cubic function was found to be the best model for future projections by 2020 AD as it has the significant Adj R^2 and also satisfied the assumption of randomness of residuals. The projected production would be positive trend at 19572 thousand tonnes by 2020 AD. Productivity of maize was projected by using inverse function which has lest RMS, significant Adj R^2 and also has showed significant runs. The future projection for productivity of maize also is in increasing trend and it would be 3320 kg/ha by 2020.AD.

Table 5 : Growth models of area, production and productivity of maize crop in Karimnagar

Model	Linear	Logarithmic	Inverse	Quadratic	Cubic	Compound	Power	S-curve	Growth	Exponential
					Area					
$AdjR^2$	0.307*	0.168*	0.025	0.307*	0.491*	0.332*	0.176*	0.025	0.332*	0.332*
RMS	369.2	443.557	519.663	369.45	271.413	362.03884	507.40912	361.27683	427.73433	361.14853
Runs	6	6	7	8	7	8	7	8	7	8
					Production					
$AdjR^2$	0.534*	0.373*	0.134**	0.533*	0.562*	0.672*	0.533*	0.26*	0.671*	0.671*
RMS	13431	18078.716	24959	13467	12617.14	13015.413	24181.738	13090.495	16355.725	13093.497
Runs	10	7	11	9	2	12	7	12	11	10
					Productivity					
$AdjR^2$	0.647*	0.527*	0.253*	0.637*	0.625*	0.665*	0.617*	0.375*	0.665*	0.665*
RMS	332884	446319	704299	342136	353467	327252.19	655211.36	325162.33	391887.59	325281.56
Runs	18	13	9	18	18	16	7	16	14	16

* indicate significance of value at P=0.05

Table 6: Future projections of area, production and productivity of maize crop in Karimnagar

Year	Area ('000'ha)	Production ('000'tonn)	Productivity(kg/ha)
2013-14	116.9	556.8	3413.8
2014-15	110.3	569.5	3416.6
2015-16	102.5	582.1	3419.2
2016-17	93.2	512.10	3421.7
2017-18	82.5	498.25	3424.1
2018-19	70.2	460.85	3426.3
2019-20	72.0	482.15	3429.0

Summary and Conclusion:

The present investigation has been undertaken to evaluate the growth in area, production and productivity of maize crop in three districts of Northern Telangana Zone. An attempt has been made to fit the trend equations to the area, production and productivity of the maize crop and best fitted model was chosen for the purpose of future prediction by 2020. The time series data pertaining to the area, production and productivity of selected maize crop in three districts of Northern Telangana Zone were collected from the Directorate of Economics and Statistics (DES) Hyderabad for the period of 34 years *i.e.*, from 1979-80 to 2012-13 and also from the district chief planning office at district head quarters. The linear growth rates and compound growth rates for the study period of 1979-80 to 2012-13 were estimated by fitting the linear function and compound function to the area, production and productivity of maize crop, respectively. The models fitted to the time series data of area, production and productivity were linear, logarithmic, inverse, quadratic, cubic, compound, S-curve, growth, power and exponential. The most important assumption of randomness of residuals was tested by using one sample run test. The model which showed relatively the least residual mean square (RMS), significant Adj R^2 and significant runs were chosen for the purpose of future projection by 2020 A.D.

Area of maize in Adilabad showed an increasing, decreasing growth pattern during the study period of 1979-80 to 2012-13. The Adj R^2 values for all the models were ranging from -0.102 in case of inverse and 0.929 in case of cubic function, only quadratic, cubic models

Table 7: Growth rates in area, production and productivity of maize crop in Nizamabad

Nizamabad (%)	Area	Production	Productivity
Linear	0.43	3.7**	3**
Compound	0.3	3.4**	3.2**
C.V.	16.52	48.72	38.35

** indicate significance of value at P=0.01

Table 8 : Growth models of area, production and productivity of maize crop in Nizamabad

Model	Linear	Logarithmic	Inverse	Quadratic	Cubic	Compound	Power	S-curve	Growth	Exponential
					Area					
AdjR^2	0.037	-0.019	-0.027	0.522*	0.931*	0.01	-0.028	-0.03	0.01	0.01
RMS	100.55	106.448	107.22	49.885	7.222	98.472025	104.61163	98.459502	104.19639	98.45838
Runs	4	6	6	6	10	6	6	6	6	6
					Production					
AdjR^2	0.563*	0.318*	0.087**	0.747*	0.812*	0.657*	0.422*	0.149**	0.657*	0.657*
RMS	3879	6054	8106.89	2244.77	1667.94	3204.9837	8012.644	3275.3097	5619.096	3275.3042
Runs	13	9	11	18	3	19	9	18	11	18
					Productivity					
AdjR^2	0.664*	0.434*	0.132**	0.697*	0.693*	0.606*	0.409*	0.13**	0.606*	0.606*
RMS	463831	781696	119769	418044	423493	420994.95	1171833.8	412604.34	690542.33	412593.19
Runs	15	13	11	16	14	15	11	15	13	15

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 9 : Future projections of area, production and productivity of maize crop in Nizamabad

Year	Area ('000'ha)	Production ('000'tonn)	Productivity (kg/ha)
2013-14	83.4	12820.3	3298.3
2014-15	91.6	13957.4	3300.3
2015-16	100.8	15161.0	3302.2
2016-17	111.0	16433.3	3304.0
2017-18	122.4	17776.0	3305.7
2018-19	134.9	19191.2	3307.4
2019-20	143.0	19572.0	3320.0

Adj R^2 values were significant at 5 per cent level of significance, The production of maize in Adilabad showed a increasing, decreasing growth pattern during the study period of 1979-80 to 2012-13. The Adj R^2 values for all the models were ranging from 0.171 in case of inverse and 0.774 in case of cubic function. Almost all the models Adj R^2 values were significant at 5 per cent level of significance; The productivity of maize in Adilabad showed a increasing, decreasing growth pattern during the study period of 1979-80 to 2012-13. The Adj R^2 values for all the models were ranging from 0.172 in case of inverse and 0.847 in case of cubic function, respectively. Almost all the models Adj R^2 values were significant at 5 per cent level of significance; all the models satisfied the assumption of randomness of residuals.

Area of maize in Karimnagar showed a increasing growth pattern during the study period of 1979-80 to 2012-13. But the last two years area decreased. The Adj R^2 values for all the models were ranging from 0.025 in case of inverse, s- curve and 0.491 in case of cubic function, except inverse function almost all the models Adj R^2 values were significant at 5 per cent level of significance, all the growth models were satisfied the assumption of randomness of residuals. The production of maize in Karimnagar showed a increasing, decreasing growth pattern during the study period of 1979-80 to 2012-13. The Adj R^2 values for all the models were ranging from 0.134 in case of inverse and 0.671 in case of compound, growth, exponential function. Almost all the models Adj R^2 values were significant at 5 per cent level of significance, but inverse function Adj R^2 value is significant at 1 per cent level of significance. All growth models were satisfied the assumption of randomness of residuals. The productivity of maize in Karimnagar showed an increasing, decreasing growth pattern during the study period of 1979-80 to 2012-13. The Adj R^2 values for all the models were ranging from 0.253 in case of inverse and 0.665in case of compound, growth, exponential function, respectively. Almost all the models Adj R^2 values were significant at 5 per cent level of significance, only inverse, power, s-curve growth models were satisfied the assumption of randomness of residuals.

Area of maize in Nizamabad showed a increasing growth pattern during the study period of 1979-80 to 2012-13. Adj R^2 values for all the models were ranging from -0.019 in case of logarithmic and 0.931 in case of cubic function, only quadratic, cubic models Adj R^2 values were significant at 5 per cent level of significance but remaining all growth models were no significant, all the growth models were satisfied the assumption of randomness of residuals. The production of maize in Nizamabad showed a increasing decrease growth pattern during the study period of 1979-80 to 2012-13. The Adj R^2 values for all the models were ranging from 0.087 in case of inverse and 0.812 in case of cubic function. Almost all the models Adj R^2 values were significant at 5 per cent level of significance, but inverse, S-curve function Adj R^2 value is significant at 1 per cent level of significance. Only logarithmic, inverse, cubic, power and growth functions were satisfied the assumption of randomness of residuals. The productivity of maize in Nizamabad showed a increasing, decreasing growth pattern during the study period of 1979-80 to 2012-13. The Adj R^2 values for all the models were ranging from 0.130 in case of S-curve and 0.697 in case of quadratic, functions, respectively. Almost all the models Adj R^2 values were significant at 5 per cent level of significance, but inverse, S-curve function Adj R^2 value is significant at 1 per cent level of significance. Only inverse, power functions were satisfied the assumption of randomness of residuals.

REFERENCES

Aparna, B., Shareef, S.M., Raju,V.T and Srinivasa Rao, V. (2008). Growth trends of major vegetables in Visakhapatnam. *The Andhra Agric. J.,* **55** (1): 68-69.

Kiran, G. V. V. (2001). Crop based classification of Telangana with regard to certain representative crops. M.Sc. (Ag.) Thesis, Acharya N.G. Ranga Agricultural University, Hyderabad, India.

Mathur, K.N. (2005). Trend analysis of area, production and productivity of rice in India. *J. Indian Soc. Agric. Statist.,* **59** (1) : 39.

Pandey, U.B. (2004). Development programmers and policies for accelerated production of vegetables in India. *Food Security and Vegetables: A Global Perspective*. 281-303.

Reddy, A. R. (1978). A contribution to rational approximation. *J. London Mathematical Society,* **2** (3): 467.https://doi.org/10.1112/jlms/s2-17.3.467-s.

Sharma, Bharati, J.K., Mandal, R.C. and Pandey, S.S. (2000). Selection of statistical models to study the growth pattern of the area and production of rapeseed and mustard. *J. Appl. Biol.,* **10** (2): 202-206.