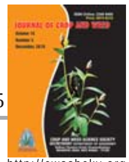
Journal of Crop and Weed, 16(1): 78-81 (2020)

ISSN- O : 2349 9400 ; P : 0974 6315



http://cwssbckv.org
www.cropandweed.com

Fitting statistical model on some agricultural dynamic variables to analyse growth of Barley (*Hordeum vulgare*) production and productivity in Jaipur district of Rajasthan

C. K. SAINI AND A. GUPTA

Department of Mathematicsand Statistics, College of Agriculture,
JNKVV- 482004 Jabalpur, (M.P.) India.

Received : 22.07.2019 ; Revised : 10.06.2020 ; Accepted : 15.06.2020

DOI: https://doi.org/10.22271/09746315.2020.v16.i1.1275

ABSTRACT

In this paper, we study stochastic models to analysis production and productivity of barley in Jaipur district of Rajasthan. There we took two dynamic variables or factors on which stochastic model has been fitted. The factor is as following Barley production (000 tones) and productivity (kg ha^{-1}). The stochastic models which used for fitting purpose as following: Linear, Quadratic, Compound, Cubic and Power,there we used three criteria to comparison among model namely (i) Adjusted R^2, (ii) Residual mean squares error (RMSE) and (iii) coefficient of determination (R^2). The model which shows the highest $R^2$and least RMSE,it would be best for a specific factor. The results indicated that the cubic, compound and power are the most suitable model to study barley production and productivity in Jaipur district of Rajasthan.

Keywords: Adjusted R^2, barley, coefficient of determination R^2, residual mean squares error (RMSE), stochastic models

Barley *(Hordeum vulgare* L.) is cultivated as a winter season cereal crop of India ranking next to wheat ; In India, 75-80 per cent of the total production is utilizing as animal food, 20-25 per cent goes as malting, 2-5 per cent used as human foodand rest of used as industrial raw material for manufacture of alcoholic drinks, data taken from economic analysis of the barley and related use. Seed is the main edible part of the plant and is a rich source ofminerals and carbohydrates, mainly cultivate for the malt production In India. Barley grain contains 12.5 per cent protein, 74 per cent carbohydrates, 1.3 per cent fat and 17.3 per cent fibers. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5411883/

A stochastic process is simply a collection of random variables over the time. It will be useful to consider separately the cases of discrete and continuous random variable. We will even have occasion to consider indexing the random variables by negative time. That is, a discrete time stochastic process X = {X_n, n = 0, 1, 2, . . .} is a countable collection of random variables indexed by the non-negative integers, and a continuous time stochastic process X = {X_t, 0 d” t < “} is an uncountable collection of random variables indexed by the non-negative real numbers. In this paper: cubic, compound and power modelis the best model for the analysis of production and productivity of barley by using three criteria of comparison namely: coefficient of determination (R^2), root mean square error (RMSE), Adjusted R^2. Mathur (1996) Analysis of trends in area, production and productivity of pulses in India. Singh (2013) they also suggest cubic and quadratic are best statistical model based on various goodness of fit criteria.Saini *et al.* (2019) study on growth rate and estimation of direct and indirect effect on total barley production.Karim *et al.* (2005) applied regression modeling to forecast wheat production of Bangladesh districts. Bharti AK (2012) fined the Pattern of growth and technological impact on oilseeds production in Uttar Pradesh.

MATERIALS AND METHODS

Data collected for 25 years from Directorate of Economics and Statistics Rajasthan, and Department of Agriculture Cooperation and Farmers Welfare, Govt of India. Observations taking during the period 1990-91 to 2014-15 for total production and productivity of barley with respect to Jaipur district of Rajasthan, given in appendix I. The production and productivity taking as (000 tones) and (kg ha^{-1}) for over thetime of 25 years.The model's value of production and productivity is given in table 1 and 2 and their respective graph given as figure 1 and 2.

Statistical model fitting

The analysis has been performed by the functional form of the above-mentioned models is

$Y_t = f(t_i\beta_j)$ i = 1, 2,…,25;.

j = 1, 2,…p, there p = j^{th} factor

Where,

Y_t = t^{th} year Barley production / productivity

β_j = unknown parameter to be estimated,

Email : schetan761@gmail.com

The five models, *viz*. cubic, compound,power,linear and quadratic, were fitted on the first 21th year data and then subsequently addedone-year data at each stage till the 25th years, being the last stage of model.

The mathematical format of following models is-

Linear : $Y_t = \alpha + \beta_1 t + \varepsilon_t$ .... (1)

Quadratic : $Y_t = \alpha + \beta_1 t + \beta_2 t^2 + \varepsilon_t$ .... (2)

Compound : $Y_t = \alpha (\beta_1)^t \varepsilon_t$. .... (3)

Cubic : $Y_t = \alpha + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + \varepsilon_t$ .... (4)

Power : $Y_t = \alpha (t)^{\beta} e \varepsilon_t$ .... (5)

(Johnson and Wichern, 2007)

Where,

$Y_{t =}$ response of the i^{th} factor in the t^{th} year

α, β = unknown parameter, to be estimated, of the model, α (constant).

ε_t = multiplicative or additive random error, $\varepsilon_t \sim$ IID N $(0, \sigma^2)$ error distributed as independently and identical with zero mean and constant variance (σ^2)

Following comparison criteria were used for model validation:

(1) Coefficient of determination

The goodness of fit is examined by using the coefficient of determination (R^2).

$$R^2 = 1 - \frac{\sum_{i=1}^{n} \left(Y_i - \overline{Y}_i\right)^2}{\sum_{i=1}^{n} \left(Y_i - \overline{Y}_i\right)^2}$$

(2) Residual variance

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n} \left(Y_i - \overline{Y}_i\right)^2}{n}}$$

The smaller the value of RMSE the better is the model.

(3) Adjusted R^2

Adjusted R-square is nothing but the change of R-square that adjusts the number of terms in a model. Adjusted R square calculates the proportion of the variation in the dependent variable accounted by the explanatory variables. The adjusted R^2 always has a lower value than R^2.

The Adjusted R^2 defined as:

$$\overline{\text{R}}^2 = 1 - \frac{\sum_{i=1}^{n} \left(Y_i - \overline{Y}_i\right)^2 / (n-k)}{\sum_{i=1}^{n} \left(Y_i - \overline{Y}_i\right)^2 / (n-1)}$$

Or $\quad R^2_{adj} = 1-(1-R^2)\,\dfrac{n-1}{n-k}$

Where k = number of parameters of the model including the intercept term.

The above mentioned criteria were carried out with regarding to productivity and production data, separate separate. The parameters of these models were estimated by ordinary least square (OLS) method. After the estimates of the criteria, judging judiciously and comparing among estimates, estimates summary *viz*, R^2; (RMSE) and Adjusted R^2values, the best fitted model was screened mainly and tested for their sufficiency with respectto the error attributes.

RESULTS AND DISCUSSION

The total production and productivity of barley are given in Appendix- I. The results obtained in course of building up to best fitting studying model,primarilyfor five models *viz*, cubic,compound,power,quadratic andlinear, were fitted for the first 21th year datum and then subsequently adding one-year data at each stage till 25th years. The result obtained by above mentioned models tabulated in table 1 and 2 by judiciously comparing among the models with regarding to adjusted R^2, RMSE, and R^2, values, the power, compound and cubic models are find out to be the best fitted models for production and productivity of barley in Jaipur district, due to smallest RMS and highest R^2 among all models.The values of bestfittedmodels withdifferent criteria *viz*, R^2, RMSE, and adjusted R^2 for barley production in Jaipur district is following.

The values obtained by cubic model for different criteria *viz*, Adjusted R^2, RMSE,and R^2 is following: 0.35 18.49,77.5 %, for year 2011,0.690,21.33,72.5 % for year 2012, 0.679, 22.01,62.7 % for year 2013,0.635,27.59,79.7 % for year 2014, and .588, 63.9 %, 26.41 for year 2015.

The values obtained by compound model for different criteria *viz*,Adjusted R^2, RMSE, and R^2 is following:.035,.0730,74.4% for year 2011, 0.731, 74.3 %,.035, for year 2012, 0.598 , .050,61.1 % for year 2013, 0.614 .048,79.4 % for year 2014 and 612, .048,62.8 %, for year 2015.

The values obtained by power model for different criteria *viz*, Adjusted R^2, RMSE and $R^2$is following, .513,.064,53.7% for year 2011, .535,.061, 55.7% for year 2012,.482,065, 50.1% for year 2013, 0.526, .062, 72.5 % for year 2014, and.519,.059,53.9 % for year 2015.

The values of best fitted models with different criteria *viz*,Adjusted R^2, RMSE, and R^2 for barley productivity in Jaipur district is following.

The values obtained by cubic model with different criteria *viz*, Adjusted R^2, RMSE, and R^2 is following

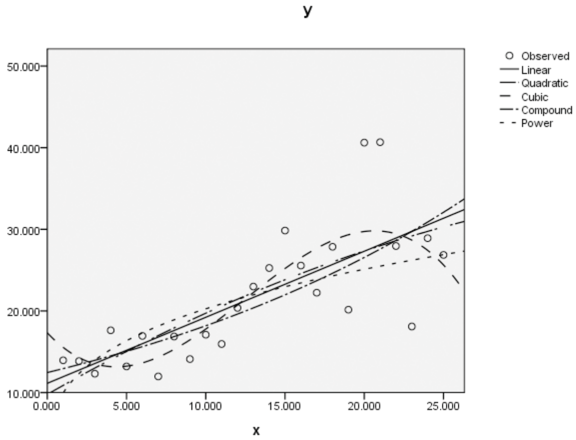


Fig. 1: Diagram showing the fitting of total barley production in Jaipur district

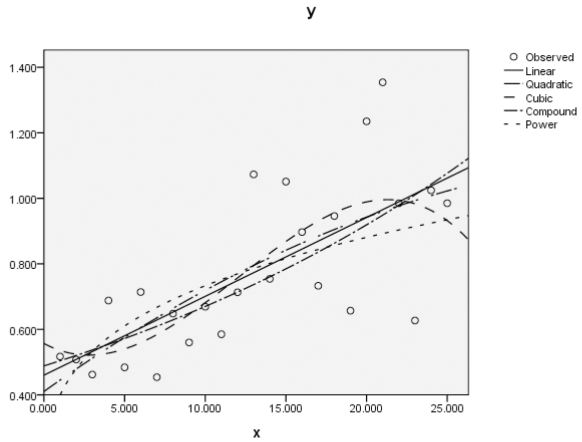


Fig. 2: Diagram showing the fitting of barley productivity in Jaipur district.

Table 1 : Values of different model criteria wise on total barley production in Jaipur district.

Models	t = 21	t = 22	t = 23	t =24	t = 25
	AdjR^2	AdjR^2	AdjR^{2}R	AdjR^{2}R	AdjR^{2}R
	RMSE	RMSE	RMSE	RMSE	RMSE
	R^2(%)	R^2(%)	R^2(%)	R^2(%)	R^2(%)
Linear	0.668	0.663	0.526	0.541	0.534
	29.89	23.11	31.28	30.16	29.89
	68.5	67.9	54.7	56.0	55.3
	0.754	0.690	0.502	0.561	0.518
Quadratic	30.92	21.33	32.83	31.58	30.92
	77.1	71.9	54.8	74.9	55.8
Cubic	0.735	0.679	0.568	0.635	0.588
	26.41	22.01	28.48	27.59	26.41
	77.5	72.5	62.7	79.7	63.9
Compound	0.048	0.035	0.050	0.048	0.048
	74.4	74.3	61.7	79.4	62.8
	0.513	0.535	0.482	0.526	0.519
Power	0.059	0.061	0.065	0.062	0.059
	53.7	55.7	50.1	72.5	53.9

.574,.028,63.8 % for year 2011,0.558,.029,62.1 % for year 2012, .035, 0.445,52.1%, for year 2013,0.461.034, 53.2 % for year 2014 and .47.033, 54.3 % for year 2015.

The values obtained by compound model for different criteria *viz*,Adjusted R^2, RMS, and R^2 is following, .609,.040,62.9 % for year 2011,.623, .039,64.1%, for year 2012, 0.48, .051, 50.8 % for year 2013, 0.512, .049,53.3 %, for year 2014, and .527, .047,54.7 % for year 2015.

The values obtained by power model for different criteria *viz*,Adjusted R^2, RMS, and R^{2}is following,.055,465, 49.1% for year 2011, .489, .052,

Table 2 : Values of different model criteria wise on total barley productivity in Jaipur district.

Models	t = 21	t = 22	t = 23	t =24	t = 25
	Adju R^2	Adj R^2	Adj R^2	AdjR^2	AdjR^2
	RMS	RMS	RMS	RMS	RMS
	R^2(%)	R^2(%)	R^2(%)	R^2(%)	R^2(%)
	0.574	.584	.442	0.470	.483
Linear	0.028	.027	.035	.153	.032
	59.6	60.4	46.8	49.3	50.4
	.592	.500	.418	0.449	.46
Quadratic	.027	.027	.036	.100	.033
	63.3	62.0	47.1	49.6	51.1
	.574	.558	.445	0.461	.47
Cubic	.028	.029	.035	.103	.033
	63.8	62.1	52.1	53.2	54.3
	.609	.623	.480	0.512	.527
Compound	.040	.039	.051	.069	.047
	62.9	64.1	50.8	53.3	54.1
	.464	.489	.420	0.450	0.470
Power	.055	.052	.057	.130	.052
	49.1	51.3	45.1	47.4	49.2

51.3 % for 2012, 0.42,.057,45.4 %, for year 2013, 0.450, .055,47.4 %, for year 2014, 470..052, 0. 49.2 % for year 2015.

By observing the table 1 and 2 we find that the value of RMS is highest of quadratic and linear model but their R^2 also be highest and we want least R^2 for a best fitted model. So, in this case we take such model which has highest or moderate RMS and least R^2 since cubic, compound and power model have the moderate RMS and least R^2 so these models best fitted to study barley production and productivity in Jaipur district.

By observing the fig. 1 and 2 we find the cubic, compound and power model are more consist and moving upward steadily. So,graph also indicates that cubic, compound and power model are more suitable to study barley production and productivity in Jaipur.

The result showed that cubic, compound and power model is best to analysis growth rate of barley production and productivity in Jaipur district.

The graph also exhibits that production and productive increasing continuously over the time.

REFERENCES

Bharti, A.K, Sharma, M.K., Sharma, H.L., Sisodia, B.V.S. and Dube, L.K. 2012. Pattern of growth and technological impact on oilseeds production in Uttar Pradesh. *J. Crop and Weed.* **8 (2):** 1-6

Directorate of Economics and Statistics (1990-91, 2014-15) Rajasthan.Economic analysis of the barley and related use.

Karim, R., Awa, A. and Akhter, M. 2005. Forecasting of wheat production in Bangladesh. *J.Agri. Soc. Sci*., 1: 120-22

Mathur, K. N. 1996. Analysis of trends in area, production and productivity of pulses in India. *J. Indian Soc Agric Stat*.**48 (1**): 80-81

Saini *et al.*, 2019. A study on growth rate and estimation of direct and Indirect effect of some influential time series production factors on total barley (*Hordeumvulgare*) Production. *Int. J. Agric. Stat. Sci.* **15**(1): 205-09.

Singh, U., Singh, R.B. and Gautam, S. S. 2013. Stochastic models for describing growth of soybean production and soya oil production in India and Madhya Pradesh *JNKVV Res. J.*,**47 (2)**: 233-38.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5411883/

Appendix- I

Data collected of total barley production and productivity of Jaipur district of Rajasthan. From Directorate ofEconomics and Statistics (1990-91, 2014-15) Rajasthan.

Year	Barley Production (‘000 tones) Jaipur	Barley Productivity (Yield kg ha^{-1}) Jaipur
1991	13.949	517
1992	13.850	508
1993	12.310	462
1994	17.620	688
1995	13.200	484
1996	16.936	714
1997	11.972	454
1998	16.867	648
1999	14.101	56
2000	17.086	669
2001	15.947	585
2002	20.370	713
2003	22.984	1073
2004	25.260	754
2005	29.848	1051
2006	25.556	897
2007	22.230	733
2008	27.860	946
2009	20.150	657
2010	40.619	1235
2011	40.674	1354
2012	27.954	0985
2013	18.089	627
2014	28.911	1245
2015	26.861	985