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A computational mathematical model for forecasting of Indian crop

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Abstract
In this paper, we have considering a forecasting of crops, such as Rice, Wheat, and Potatoes of Indian data from 2000 to 2019 year. Mathematical model with regression equation used for forecasting of Indian crop data. Where output experimental result use for the forecasting of next year production of the data.

Keywords: Forecasting, regression equation, crops, wheat, rice, potatoes

Introduction
For the forecasting of the production of the crop have several methods, which based on theoretical calculation and software calculation. Related work of crop production and agricultural field are completed by many agricultural and other field experts. For this paper, we also search some previous work and discuss it. Zhang *et al.* [1] applied single- variable regression in rice grain/vegetables versus natural log-transformed concentration in soil on cropland of China. Hare [2] discussed on the impact of defoliation on Potato yield and applied experiment was repeated seven times in intervals, where one interval is equal to two weeks. Risk- neutral and risk-averse formulations are applied on northeastern Oregon farms data by Nazer *et al.* [3]. Regression based model applied to estimate the impact of multiple pets on crop productivity by Johnson [4]. Gandhi *et al.* [5] applied a neural network for predict the rice production of districts of Maharashtra.

Regression Model
A good measure of the relationship between two variables is given by the coefficient of correlation which tells about strength and direction of a relationship. After correlation between two variables, we determine a mathematical relationship between them to achieve the following:

1. The value of a variable based on the other variable could be predicted.
2. How does the change in the value of one variable could impact the other explained.

For geometrical convenience and ease, we fit a linear relationship and analyze a regression model. The term regression was coin by Sir Francis Galton in 1885. To figure out the predictive power of an independent variables on the dependent variables there is a term used which is known as "Regression". It deals with the way changes in one variable based on how one or more other variables changes. Regression provides more information rather than correlation.
Dependent and independent variables:
Out of the two variables is considered dependent variable and other one is considered independent variable. For example, out of rainfall and yield of crop rainfall is independent and yield is dependent.

1. Simple linear Regression Model: It is a relation between one explanatory variable (X) and one response variable (Y). The simplest relationship is given by X and Y.

$$Y = a + b\,X + e$$

Where, the dependent variable is Y, the independent variable is X, a constant, b is coefficient and e represents error.

2. Multiple Linear regression Model: In some cases, the response variable Y may depend on

more than one explanatory variable.

$$Y = a + bX_1 + bX_2 + \cdots + bX_n + e$$

In this case, Y represents the dependent variable and e is the error. But here we can see the independent variable is present more than one.

Nomenclature

Multiple_R	Coefficient of correlation
R^2	Coefficient of determination
SS	Sum of Squares
MS	Mean squared error
F	Overall test for the null hypothesis
T-State	Computed t statistic for intercept and slope
Lower 95% and Upper 95%	Confidence interval estimate of intercept and slope

Mathematical calculation processes

For the calculation of production of rice in India from 2000 to 2019 by Regression model. In Table 1 show a year wise production of rice in India from 2000 to 2019. Figure 1 is a graphical representation of rice data with linear equation.

Table 1: Year-wise production data of rice in India

Year	Production	Year	Production
2000	84977	2010	95970
2001	93334	2011	105301
2002	71814	2012	105241
2003	88552	2013	106646
2004	83127	2014	105482
2005	91785	2015	104408
2006	93345	2016	109698
2007	96682	2017	112760
2008	99172	2018	116420
2009	89083	2019	115000

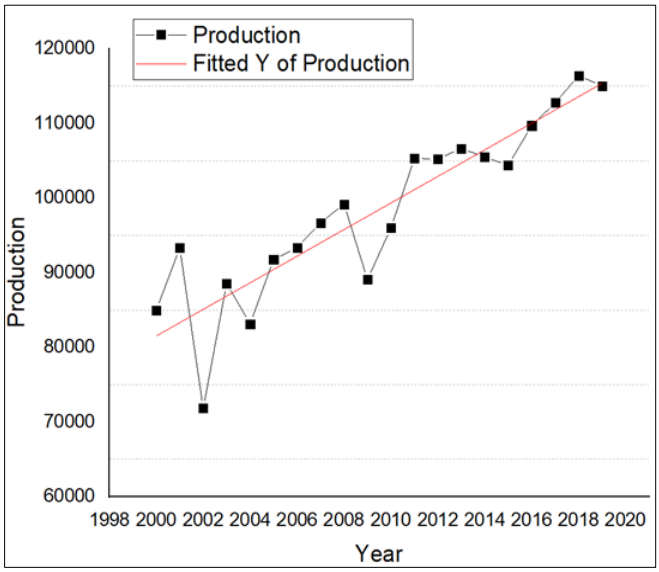

Fig 1: Production of Rice in India

Applied regression model on rice (2000-2019) data of India and get the calculated values by software. i.e.

Input/output expression of Rice production

Multiple_R	21
R_Square	0.815266
Adjusted R_Square	0.805003
Standard Error	5156.938
Observations	20

	df	SS	MS	F	Significance F
Regression	1	2.11E+09	2.11E=09	79.43728	5.09E-08
Residual	18	4.79E+08	26594009		
Total	19	2.59E=09			

Coefficients	Standard	Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-3483195	401856.4	-8.66776	7.68E-08	-4327464	-2638926	-4327464	-2638926
Year	1782.351	199.9775	8.912759	5.09E-08	1362.214	2202.488	1362.214	2202.488

For the calculation of production of wheat in India from 2000 to 2019 by Regression model. Table 2 shows a year-wise production of wheat in India from 2000 to 2019. Figure 2 is a graphical representation of rice data with a linear equation.

Table 2: List of wheat production data over area and years

Year	Area Harvested	Production	Year	Area Harvested	Production
2000	27486	76369	2010	28457	80804
2001	25731	69681	2011	29069	86874
2002	26345	72766	2012	29865	94882
2003	25196	65761	2013	30003	93506
2004	26595	72156	2014	30473	95850
2005	26383	68637	2015	31466	86527
2006	26484	69355	2016	30220	87000
2007	27995	75807	2017	30785	98510
2008	28039	78570	2018	29651	99870
2009	27752	80679	2019	29850	102190

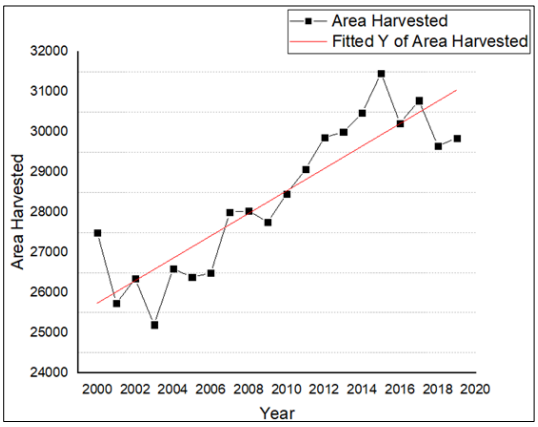

Fig 2: Area Harvested of wheat

The yearly production of wheat from 2000-2019 with linear equation form is shown in figure 3 and production over area harvested are shown in a graphically form in figure 4.

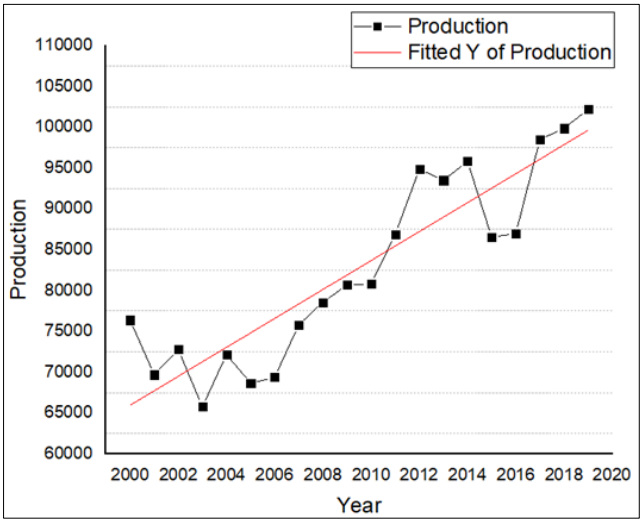

Fig 3: Production of Wheat

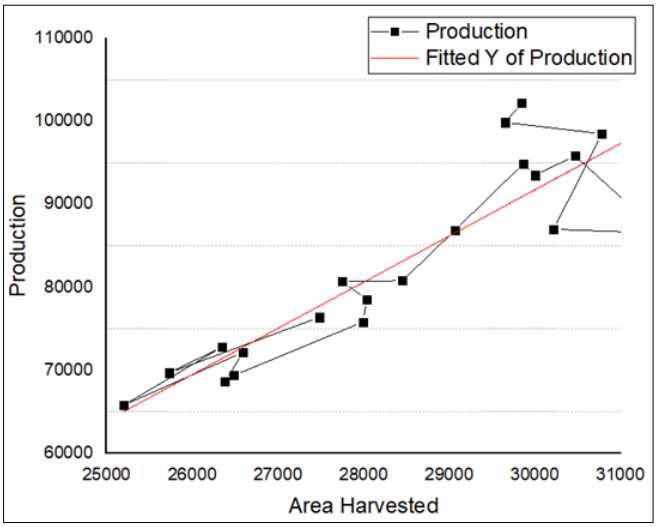

Fig 4: Production over area harvested

Input/output expression of Wheat production

Multiple_R	**0.890971**
R_Square	0.79383
Adjusted R_Square	0.782376
Standard Error	5422.994
Observations	20

	df	**SS**	**MS**	**F**	**Significance F**
Regression	1	2.04E+09	2.04E+09	69.30659	1.38E-07
Residual	18	5.29E+08	29408869		
Total	19	2.57E+09			

	Coefficients	**Standard Error**	**t Stat**	**P-value**	**Lower 95%**	**Upper 95%**	**Lower 95.0%**	**Upper 95.0%**
Intercept	-75362.4	19035.78	-3.95899	0.00092	-115355	-35369.7	-115355	-35369.7
Area harvested	5.570257	0.669095	8.325058	1.38E-07	4.16454	6.975974	4.16454	6.975974

Similarly, for the calculation of production of potato in India from 2000 to 2018 by Regression model. Table 3. Show a year-wise production of potato in India from 2000 to 2018. Figure 3 is a graphical representation of rice data with a linear equation.

Table 3: Production of Potato in India 2000-2018

Year	**Area**	**Yield**	**Production**	**Year**	**Area**	**Yield**	**Production**
2000	1.32	17886	23.61	2010	1.83	18810	34.39
2001	1.34	18443	24.71	2011	1.84	19951	36.58
2002	1.22	18404	22.49	2012	1.86	22724	42.34
2003	1.21	19806	23.92	2013	1.91	21753	41.48
2004	1.35	17300	23.27	2014	1.99	22760	45.34
2005	1.29	17887	23.06	2015	1.97	21060	41.56
2006	1.32	17923	23.63	2016	2.08	23126	48.01
2007	1.4	17508	23.91	2017	2.12	20509	43.42
2008	1.48	14943	22.18	2018	2.18	22303	48.6
2009	1.55	18331	28.47				

Input/output expression of Potato production

Multiple_R	**0.999137**
R_Square	0.998274
Adjusted R_Square	0.998058
Standard Error	0.443823
Observations	19

	df	**SS**	**MS**	**F**	**Significance F**
Regression	2	1822.912	911.4562	4627.175	7.87E-23
Residual	16	3.151663	0.196979		
Total	18	1826.064			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-33.3413	0.957014	-34.8389	1.62E-16	-35.3701	-31.3125	-35.3701	-31.3125
Area	19.89155	0.479728ss	41.46423	1.03E-17	18.87457	20.90853	18.87457	20.90853
Yield	0.001703	7.23E-05	23.54237	7.64E-14	0.00155	0.001857	0.00155	0.001857

Result and Discussion

Mathematical model with regression model applied on Indian crop of 2020. Crop of Rice production hypothesis is rejected at significance level should be less than 0.5. Calculated value of R square is 0.8153 with standard error 5156.938. The standard error in intercept and Year are 401856.4 and 199.9775, respectively. For year 2020 production of rice is 117154.02 (1000 MT). Crop of Wheat production output expression show the R_square value is closer to 1. Suppose area is 30395 (1000/HA) then predicted production of wheat is 93947.2685 (1000 MT) of next year. Production of Potato depends on area and yield of crops where apply the multiple linear regression model for calculate the Potato production of data 2000-2018. Calculated values of R, R_square, and estimate the standard error are 0.999137, 0.998274, and 0.443823, respectively. And higher significant level ($p< 0.05$). If Potato production such as Area = 2.5 (Million HA) and Yield = 206000 (kg/HA) then Predicted production is 51.47 (Million Tons). Such as selected crops of India and its Regression line equation for each crop production by changing area, yield and year in variables:

1. Wheat (Y = -3483195 + 1782.351X)
2. Rice (Y = -75362.4 + 5.5703X)
3. Potato ($Y = -33.3413 + 19.89155X_1 + 0.001703X_2$)

Where Y is dependent variable and X, X_1, X_2 are independent variables.

Conclusion

From this paper analysis we conclude that predicted production analysis of rice in India 2020 descripted as an increasing factor with respect to the previous years, which is highest in recorded data. In present, the study of wheat production analysis significance is short according to the last three years of the data. Most demanded crop in the market is Potato. So, Predicted production analyses of potato in India are high progress compare to the last twenty years.

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