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Influence of area and yield on the production of maize in Chhattisgarh Plain

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Abstract
Predictive models for the maize crop (*Zea maize* L.) of Chhattisgarh plain and its constituent districts have been made. Models have been fitted for the area, productivity and production of the crop separately for above region. Based on these models prediction of area productivity and production of maize have been made year wise between 1998-99 to 2013-14. The partial compound growth rates of the area, production and productivity of the crop have been also estimated and discussed. Periodic effect of five years as well as annual effects was found to be working in most of the districts/region based on a postulated and estimated production function of area and productivity. It was found that the major influencing factor on the production of maize was its area and productivity for different districts. This influence of area and productivity was around 7 and 22 percent for the Chhattisgarh plain respectively.

Keywords: Growth Rate, Area, Production, Maize

1. Introduction

Maize is a cereal crop which is cultivated widely throughout the world and has the highest production among all the cereals. Global production of maize has grown at a CAGR of 3.4 % over the last ten years, from 717 MnMT in 2004-05 to 967 MnMT in 2013-14. The area under maize cultivation in the period has increased at a CAGR of 2.2 %, from 146 Mn hectares in 2004-05 to 177 Mn hectare in 2013-14, the remaining increase in production is due to increase in yield. Productivity of maize has increased at a CAGR of 1.2 %, from 4.9 MT/hectare in 2004-05 to 5.5 MT/ hectare in 2013-14.

India accounts for only about 2.4 % of the world's geographical area and 4 % of its water resources, but has to support about 17 % of the world's human population and 15% of the livestock. Agriculture is an important sector of the Indian economy, accounting for 14% of the nation's GDP, about 11% of its exports, about half of the population still relies on agriculture as its principal source of income and it is a source of raw material for a large number of industries. It occupies 32% of the area under food grains and contributes 42% of total food grains production in the country. During 2011-12, there was record production of food grains at 259.32 million tones, of which 131.27 million tones was during Kharif season and 128.05 million tons during the Rabi season. Of the total food grains production, production of cereals was 242.23 million tones.

The normal maize grain under Indian conditions on an average, contains 14.9% moisture, 9 to 11% protein, 3.6% fat, 2.7% fiber, 66.2% other carbohydrates and 1.5% minerals (NIN, 2002). In India, about 28% of maize produced is used for food purpose, about 11% as livestock feed, 48% as poultry feed, 12% in wet milling industry (for example starch and oil production) and 1% as seed (AICRP on Maize, 2007).

Agriculture is counted as the chief economic occupation of the Chhattisgarh state. According to a government estimate, net sown area of the state is 4.828 million hectares and the gross sown area is 5.788 million hectares. About 80% of the population of the state is rural and the main livelihood of the villagers is agriculture and agriculture based small industry. The present study is therefore, an attempt had been made to develop reliable predictive models for the area, production and productivity of maize for Chhattisgarh Plain, its constituent districts. Production function had also been developed to know the extent of influence of area and productivity on production.

2. Materials and Methods

The secondary data on area, productivity and production of maize crop were collected for the period 1998-99 to 2013-14 from the web site of Chhattisgarh Government www.cgstate.gov.in. In this period there are ten districts in Chhattisgarh plain namely Raipur, Mahasamund, Dhamtari, Durg, Rajnandgaon, Kawardha, Bilaspur, Janjgir, Korba and Raigarh due to the formation of new districts.

During analyses it was realized that a five year periodic effect is working on the response variable in most of the districts/region. Therefore, this periodic effect was considered as a structural effect changing every five years the area, production and productivity scenario of maize crop probably due to some research or technical break-through, etc. After fitting such structural/ periodic effects, i.e. α's, it was found in most cases that they were showing a trend over the three periods in almost all districts and slopes (β's) were not significantly different for these periods. Due to these reasons a periodic effect variable 'P' was introduced to measure the periodic trend along with the annual effect variable 'T' to measure annual trend with in each period. So, the following multiple regression models was finalized and fitted in all cases using stepwise regression technique as described

$$\text{Ln } Y = \text{lnt} + \text{bp P} + \text{bt T} + \epsilon \quad (1)$$

$$\text{Or ln } \hat{Y} = \text{lnt} + \text{bp P} + \text{bt T} \quad (2)$$

Where, ln $\hat{Y}$ = expected value of the natural logarithm of the response variable.

Y = area, productivity (i.e. yield) or production of given a region.

lnt = intercept.

P= periodic time Variable, taking values from 1 to 3 signifying Pd I, i.e., first period for 1998-99 to 2003-04, Pd II for 2004-05 to 2008-09 and Pd III for 2009-10 to 2013-14.

T = annual time variable taking values from 1 to 5 signifying the 1^{st}, 2^{nd}, 3^{rd}, 4^{th} or 5^{th}, year for any period 1 to 3.

bp = partial linear regression coefficient corresponding to variable P.

bt = partial linear regression coefficient corresponding to variable T.

ϵ = error/disturbance component.

Let T be fixed at a particular position in any period, i.e. at 1^{st}, 2^{nd} or 3^{rd} etc. so that it may be considered constant within any period while P varies. Then we may write (2) in the form

$$\widehat{ln}\, Y = C + b_pP, \text{ where } C = \text{lnt (since } b_t = 0 \text{ for constant T)} \quad (3)$$

$$\text{or, } Y_x = a e^{\theta x}, \text{ where } Y_x = Y,\ a = e^c,\ \theta = b_p,\ x = P \quad (4)$$

On putting x= 0 and 1 respectively in equation (4), gives Y_0 = a and $Y_1 = ae^{\theta} = Y_0(1+r_1)$, where $(1+r_1) = e^{\theta}$, say. Then, we have $\%r_1 = \{(Y_p-Y_{p-1})/Y_{p-1}\}$ 100 for fixed T. Also, $r_1 = e^{\theta} - 1 = 1 + \theta - 1 = \theta = b_p$ (higher powers of θ in e^{θ} may be ignored). Therefore, r_1 may be defined as the proportional rate of growth in response variable Y per unit change of P for fixed T, i.e., a partial compound growth rate. Similarly r_2 and b_t can be interpreted with respected to variable T.

Lastly, our interest is to find the extent of influence of area and productivity on the production of cereal crops in Chhattisgarh plain. For that it needs an additive model with an error term. We have the identity,

Production = Area × Productivity.

However, in actual practice the area, production and productivity are not always reported to be accurate enough to equal to above product, due to probably rounding errors and many a times due to human error in recording the data. Therefore, assuming that actual area, production and productivity are some powers of the reported data and representing the residual discrepancies with an error term, this identity can be written in the functional form. Then, after taking natural logarithms, denoting the error compound by $\epsilon' \sim N(0, \sigma_\epsilon^2)$ and then introducing the intercept term we can have the following linear statistical model

$$\widehat{ln}\, P(A, Y) = c_0 + c_1 \ln A + c_2 \ln Y + \epsilon' \quad (5)$$

$$\text{or, } \widehat{ln}\, P(A,Y) = c_0 + c_1 \ln A + c_2 \ln Y \quad (6)$$

$$\text{or, } \hat{P}(A,Y) = d_0 A^{c1} Y^{c2},\ d_0 = e^{c0} \quad (7)$$

Where A, Y and $\hat{P}$ (A, P) denote the area, productivity and estimated production of a given region. The constant c_0 is the intercept and (c_1, c_2) are the partial regression coefficients corresponding to variables ln A and ln Y respectively.

3. Results and Discussion

3.1. Partial Compound Growth Rate

Partial compound growth rate of area, production and yield of maize was for period (1998-99 to 2012-13) and presented in Table 1. It was observed that from the Table 1. Chhattisgarh plain had registered statistically significant increasing periodic partial compound growth rate in productivity (15.770 percent) and production (18.212 percent) at 5 percent level. The time variable didn't show significant growth rate for area, production and productivity. Among all districts of the Chhattisgarh plain zone for Raipur, Mahasamund, Durg and Kawardha districts the model showed significant partial regression for the periodic variable area. Durg and Korba districts showed significant partial regression coefficient for time variable.

The model showed significant partial regression coefficient for Raipur, Dhamatari, Durg, Janjgir and Raigarh districts for the variable production. No any district except Mahasamund (10.38 %) showed significant regression coefficient for time variable under study. While studying productivity the table 1 revealed that only Raipur, Kawardha and Raigarh districts showed significant partial growth rate. It can also be observed from the table that no any district including complete Chhattisgarh plain zone showed significant growth rate for the time variable.

Table 1: Prediction models (w.r.t time) of area and production under maize for C.G. plain and its constituent districts using model (1) for period 1998-99 to 2013-14

District/Region		lnt	bp	%r_1 @	bt	% r_2 @	% R^2
Raipur	A	-1.4139	0.4516*	57.0762	0.2193	24.5199	44.56
	Y	6.5939	0.1503**	16.2193	0.0175	1.7625	34.96
	P	-1.6892	0.5952**	81.3466	0.2301	25.8787	49.91
Mahasamund	A	-1.4120	-0.1992***	-18.0588	-0.0399	-3.9136	52.06
	Y	6.5486	0.1034	10.8951	0.0920	9.6316	25.82
	P	-2.2102	0.0081	0.8086	0.1038*	10.9362	22.03
Dhamatari	A	-2.3862	0.1023	10.7666	0.1471	15.8475	2.07
	Y	8.3337	-1.0847	-66.2008	0.0219	2.2187	6.30
	P	-3.5078	0.9335***	154.3398	0.1647	17.9079	54.78
Durg	A	-2.1968	0.2239*	25.0887	0.1229*	13.0785	42.38
	Y	6.7257	0.1160	12.3052	0.0005	0.0539	14.14
	P	-2.5318	0.3788***	46.0525	0.1389	14.8999	66.33
Rajnandgaon	A	0.4543	-0.0943	-8.9989	0.0031	0.3124	7.11
	Y	6.7831	0.0757	7.8647	0.0275	2.7863	12.32
	P	0.3414	-0.0202	-1.9984	0.0283	2.8655	1.53
Kawardha	A	1.3786	-0.1234***	-11.6058	-0.0286	-2.8158	83.03
	Y	6.5783	0.1403*	15.0595	0.0387	3.9456	26.71
	P	1.0440	0.0182	1.8386	0.0107	1.0733	1.01
Bilaspur	A	1.7069	-0.0566	-5.5023	-0.0431	-4.2152	22.76
	Y	6.8113	0.1782***	19.5122	-0.0058	-0.5795	44.69
	P	1.6097	0.1221	12.9896	-0.0490	-4.7811	20.45
Jajgir	A	-0.8785	0.0230	2.3293	-0.0254	-2.5124	14.85
	Y	6.9264	0.1019	10.7294	0.0283	2.8654	17.16
	P	-1.0141	0.1602*	17.3797	0.0230	2.3261	27.74
Korba	A	1.6327	-0.0190***	-1.8797	-0.0084**	-0.8394	75.42
	Y	6.8381	0.1146	12.1447	0.0134	1.3480	20.01
	P	1.5627	0.0957	10.0461	0.0050	0.5022	15.20
Raigarh	A	0.0199	-0.0103	-1.0275	-0.0194	-1.9180	6.00
	Y	6.9719	0.1161*	12.3142	0.0160	1.6092	23.09
	P	0.0779	0.1087*	11.4846	-0.0039	-0.3887	19.94
Plain Zone	A	2.7368	0.0209	2.1100	0.0204	2.0649	13.74
	Y	6.7621	0.1464**	15.7695	0.0136	1.3710	33.03
	P	2.5911	0.1673**	18.2123	0.0341	3.4642	31.67

***, **, *significant at 1%, 5% and 10% level of significance respectively

@ % r_1& r_2 indicate the partial compound growth rates (in percentage) corresponding to bp (partial linear regression coefficient corresponding to periodic effect variable 'P') and bt (partial linear regression coefficient corresponding to time variable 'T') respectively.

3.2. Production function of maize

To know the extent of influence of area and productivity on the production of maize postulated production function is given by equation(s) 5, 6, 7. The estimated functions in terms of area and productivity had computed and presented in Table 2.

Table 2 revealed that for all districts the production function satisfactorily fits to the data as indicated by more than 70 percent only for Kawardha district. The model showed highlyest R^2 up to 83.536 percent for Kawardha district. The column designated (1) and (2) gives the breakup of the total percent sum of squares explained by the production component, ln P (A, Y) in to its percent sum of square explained by the area component ln A and the yield component ln Y. These columns (1) and (2) showed that in most of the district's the productivity influence the area of maize by more than 38 percent barring the districts Dhamatari, Rajnandgaon, Bilaspur, Janjgir and Raigarh districts. For the district Dhamatari, Bilaspur and Raigarh the productivity was influenced by the production and only a little contribution is made by the area.

Table 2: Production function as influenced by the area and productivity of maize in Chhattisgarh andits constituent districts for period 1998-99 to 2013-14

Districts/Region		Production Function							(1)*	(2)$	(3)@
Raipur	ln P (A, Y) =	1.4249	+	0.1021	ln A	+	0.2706	ln Y	38.955	10.939	49.894
Mahasamund	ln P (A, Y) =	1.8270	-	0.4307	ln A	+	0.0941	ln Y	50.037	3.071	53.108
Dhamatari	ln P (A, Y) =	4.2689	+	0.2069	ln A	-	0.0945	ln Y	0.859	66.708	67.567
Durg	ln P (A, Y) =	1.4309	+	0.3122	ln A	+	0.3334	ln Y	39.422	26.607	66.029
Rajnandgaon	ln P (A, Y) =	1.6955	-	0.1329	ln A	+	0.2367	ln Y	6.207	9.842	16.050
Kawardha	ln P (A, Y) =	4.4017	-	1.1808	ln A	+	0.0220	ln Y	83.448	0.088	83.536
Bilaspur	ln P (A, Y) =	0.8551	-	0.3810	ln A	+	0.4228	ln Y	15.890	34.490	50.380
Janjgir	ln P (A, Y) =	1.4531	+	0.0792	ln A	+	0.2687	ln Y	0.677	14.475	15.152
Korba	ln P (A, Y) =	13.1590	-	5.9955	ln A	-	0.0604	ln Y	66.083	0.453	66.536
Raigarh	ln P (A, Y) =	0.7102	+	0.0669	ln A	+	0.3604	ln Y	0.978	19.482	20.460
Plain Zone	ln P (A, Y) =	0.2628	+	0.1270	ln A	+	0.3800	ln Y	6.546	22.702	29.248

*percent sum of squares explained by ln A, i.e. area effect
$percent sum of squares explained by ln Y, i.e. yield effect
@ Total percent sum of squares explained by ln P(A, Y) i.e. by the model (3)

Table 3: Prediction of area, productivity and production under maize crop for Chhattisgarh plain and its constituent districts for 2008-09to 2015-16*

District/Region		Year								% increase/ Decrease
		2008-09**	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	
Raipur	A@	1.17	1.46	1.82	2.27	2.82	1.84	2.3	2.86	144.44
	Y	1167	1188	1209	1230	1252	1356	1380	1405	20.39
	P	1.39	1.75	2.2	2.77	3.48	2.51	3.16	3.98	186.33
Mahasamund	A	0.13	0.12	0.12	0.11	0.11	0.11	0.1	0.1	-23.08
	Y	1044	1145	1255	1376	1508	1158	1269	1391	33.24
	P	0.12	0.14	0.15	0.17	0.19	0.13	0.14	0.15	25
Dhamtari	A	0.14	0.17	0.19	0.23	0.26	0.16	0.19	0.22	57.14
	Y	164	168	172	175	179	56	57	58	-64.63
	P	0.58	0.69	0.81	0.95	1.12	1.48	1.74	2.06	255.17
Durg	A	0.25	0.28	0.31	0.36	0.4	0.31	0.35	0.39	56
	Y	1181	1182	1183	1183	1184	1327	1327	1328	12.45
	P	0.28	0.33	0.38	0.43	0.5	0.42	0.48	0.55	96.43
Rajnandgaon	A	1.19	1.19	1.2	1.2	1.21	1.08	1.09	1.09	-8.4
	Y	1139	1170	1203	1237	1271	1228	1263	1298	13.96
	P	1.36	1.4	1.44	1.48	1.53	1.33	1.37	1.41	3.68
Kawardha	A	2.66	2.59	2.52	2.45	2.38	2.35	2.29	2.22	-16.54
	Y	1139	1184	1231	1279	1330	1310	1362	1416	24.32
	P	3.03	3.06	3.1	3.13	3.16	3.09	3.12	3.15	3.96
Bilaspur	A	4.46	4.27	4.09	3.92	3.75	4.21	4.03	3.86	-13.45
	Y	1541	1532	1523	1514	1506	1842	1831	1820	18.11
	P	6.87	6.54	6.23	5.93	5.65	7.76	7.39	7.04	2.47
Janjgir	A	0.43	0.42	0.41	0.4	0.39	0.44	0.43	0.42	-2.33
	Y	1423	1464	1506	1549	1593	1576	1621	1667	17.15
	P	0.6	0.61	0.63	0.64	0.66	0.7	0.72	0.74	23.33
Korba	A	4.79	4.75	4.71	4.67	4.64	4.7	4.66	4.63	-3.34
	Y	1333	1351	1369	1388	1407	1495	1515	1536	15.23
	P	6.39	6.42	6.46	6.49	6.52	7.03	7.07	7.1	11.11
Raigarh	A	0.97	0.95	0.93	0.92	0.9	0.96	0.94	0.92	-5.15
	Y	1535	1560	1585	1610	1636	1724	1752	1780	15.96
	P	1.49	1.49	1.48	1.47	1.47	1.66	1.66	1.65	10.74
Plain Zone	A	16.77	17.12	17.47	17.84	18.2	17.13	17.48	17.84	6.38
	Y	1360	1378	1397	1416	1436	1574	1596	1618	18.97
	P	22.81	23.6	24.42	25.26	26.14	26.96	27.9	28.86	26.52

*predicted value = exp (lnt + bp P + bt T), where lnt = intercept; bp and bt the partial regression coefficient corresponding to P and T cariables respectively.

** For 2008-09 to 20012-13, T= 1 to 5 for fixed P= 3; and for 2013-14 to 2015-16 T= 1 to 5 for fixed P= 4.

@ A: area in 000' ha, Y: productivity in kg/ha, P: production in 000' tones

3.3 Prediction of area, yield and production for 2008-09 to 2015-16

From Table 3 a prediction of area, yield and production of maize for the present year (2013-14), five back years (2008-09 to 2012-13) and future two years (2014-15 to 2015-16) based on the prediction models estimated in the present study. It is expected that the productivity of maize in Chhattisgarh plain will increase from 1360 to 1618 kg/ha, {((1618-1360)/1360)100 = 18.97%}, by the turn of this decade, if the present growth trend in productivity is maintained. Since the increasing in area is going to be {((17.84-16.77)/ 16.77)100 = 6.38%}, the 18.97% rate of increases in productivity is going to be grossly inadequate food grain to cater to the food requirement of ever increasing population. It is therefore, necessary that special effort should be made to identification major constraints and gaps in technologies, So that the adaptation of improved technologies may be made more effective and which may ultimately result in improving the productivity at a much faster rate than the existing rate. Similarly other predictions for different districts/region may be obtained from the estimated models presented in table 3.

4. Conclusion

It may be concluded that more area are being brought under maize in Chhattisgarh plain at a non-significant periodic partial compound growth rate of 2.11 percent after fifth year and within each fixed period at a non-significant annual partial compound growth rate of 2.06 percent. Rajnandgaon, Durg, Jajgir, Korba, Dhamatari and Mahasamund have non-significant trends in yield, indicating a lack of impact of new technologies in these areas. The production is more influenced by the area (30-60%) than by the yield. By the turn of this decade, the increase in area and productivity under maize is going to be (6.38% and 18.97% per annum respectively) compared to the oil requirement of ever increasing population. Therefore, productivity demands more attention than area. It is therefore necessary that special efforts should be made to identify the major constraints and gaps in technologies so that the adoption of improved technologies so that adoption of improved technologies may be made effective in improving the productivity at a much faster rate than existing rate.

5. References

1. Anonymous. Agricultural statistics, Directorate of Agriculture, Government of Madhya Pradesh, India, 1998-99, 2012-13.
2. Anonymous. Basic Agricultural Statistics, Commissioner of Land Records and Settlement Gwalior, Govt. of Madhya Pradesh, 1998-99, 2012-13.
3. Ghosh BK. Determinants of the change in cropping

pattern in India: 1970-71 to 2006-07. Bangladesh Development Studies. 2011; 34(2).
4. AdiqaKiani. An analysis of productivity growth and rate of return to researchin agriculture sector of North West Frontier province. Sarhad Journal of Agriculture. 2008; 24(3):521-530.
5. Alok Shrivastava, Saxena RR, Lakhera ML, Imran Khan, Sanjay Dwivedi. Annals of Biology. 2005; 21(1):111-118.
6. NIN. National Nutrition Monitoring Bureau, Hyderabad, 2002.
7. Arun Kumar, Mor BS. To analyse the growth rates in area, production and productivity of major crops in Haryana. Research on Crops. 2001; 2(3):327-331.
8. Ahmad MS, Yadava HS. Trends in area, production and productivity of coarse cerealsin Madhya Pradesh. Advances in Plant Sciences. 1999; 12(1):191-194.
9. Singh *et al.* Predictive models for the Area, Yield and Production of Rice in Chhattisgarh and itsconstituent's district along with the influence of Area and Yield on the Production-A different approach. Farm Sci. J. 1993, 6-9.
10. Johnston J. Econometrics Methods, McGraw-Hill Inc., New York, 1984, 207-233.
11. Draper NR, Smith H. Applied Regression Analysis, John Wiley and Sons, New York, 1981, 241-256, 307-313.