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Trends analysis of area, production and productivity of mango crops in Chhattisgarh

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Abstract
The predictive model for Mango crop (*Mangifera indica*) of Chhattisgarh has been made. Models have been fitted for the area, production and productivity of the crop separately for the districts of Chhattisgarh. The state has 27 districts out of which only 16 districts are undertaken for study on the basis of availability of secondary data during 2009-10 to 2013-14. The partial compound growth rates of the area, production and productivity of the mango have been also estimated and discussed. The productivity of mango crops are expected to increase in future as prediction model has been predicted. It was observed that the compound annual growth rate of mango in terms of productivity is negative during the 2009-10 to 2013-14 periods, even though the area under the cultivation of mango crop and its production was positive.

Keywords: Area, production and productivity of mango

Introduction
Mango is a fruit crop which is cultivated widely throughout the world and has the highest production among all the fruits crops. The horticultural growth in Chhattisgarh has been subject of research for several scholars. This has an issue of great concern for the state especially in terms of the issue of food security. Alternative measures are thus required to counteract the declaration in agricultural growth. A change in the cropping pattern of the state from low value crops to high value crops can have far reaching effect in offsetting the declaration in horticultural growth.
The total area and production of the fruits crops in the state was 185186.13 ha and 1569180.54 MT. respectively during 2011-12.According to National Horticulture Mission (NHM) and Department of Horticulture, Raipur, Chhattisgarh.

Materials and Methods
The secondary data on area, production and productivity of mango crops were collected for the period 2009-10 to 2013-14 from the website of www.cgnhm.gov.in. In the study namely; Raipur, Mahasamund, Dhamtari, Durg, Rajnandgaon, Kawardha, Jagdalpur, Kanker, Dantewada, Bilaspur, Janjgir, Korba, Raigarh, Jashpur, Surguja, Koria. In the present study we have investigated about all districts as mentioned above. Mango crops were considered for the study, because most of the districts of Chhattisgarh had some appreciable area under mango crops.

Prediction model for Periodic Effect and Annual Trend
The 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 described as

$\ln Y = \ln t + bp\ P + bt\ T + \ldots\ldots\ldots(1a)$
Or $\ln \hat{Y} = \ln t + bp\ P + bt\ T \ldots\ldots\ldots(1b)$

Where, ln = expected value of the natural logarithm of the response variable.
Y = area, productivity (i.e. yield) or production of given a region.

ln t = intercept.
P= periodic time variable, taking values from 2009-10 to 2013-14,
T = annual time variable taking values from 1 to 5 signifying the 1, 2, 3, 4, or 5, for any period 1 to 3.
bp = partial linear regression coefficient corresponding to variable P.
bt = partial linear regression coefficient corresponding to variable T.
e = error/disturbance component.

Lastly, our interest is to find the extent of influence of area and productivity on the production of fruits and vegetables crops in Chhattisgarh. For that we need an additive model with an error term. We have the identity,

Production = Area ´ Productivity……..... (2)

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 'N (0, 1) and then introducing the intercept term we can have the following linear statistical model

$\hat{} \ln P(A, Y) = c_0 + c_1 \ln A + c_2 \ln Y$ ……..……..(3a)
Or, $\hat{} \ln P(A, Y) = c_0 + c_1 \ln A + c_2 \ln Y$….....(3b)
Or, $\hat{} P(A, Y) = d_0 A^{c1} Y^{c2}$, $d_0 = e^{c0}$ ….....(3c)

Table 1: Prediction Models (w.r.t time) of Area and Production under Mango for Chhattisgarh for Period (2009-10 to 2013-14)

District/Region		Lnt	bp	%r1 @	bt	% r2 @	% R^2
Raipur	A	0.56	0.25**	29.22***	-0.06*	-6.10	18.79
	Y	9.24	0.25**	29.22***	10.65*	11.24	0.82
	P	10.27	0.10	0	0.10	11.24	8.26
Mahasamund	A	4.77	-0.12	-21.60***	0.08	-16.93	21.90
	Y	7.95	-0.94	66.24**	-19.18	-31.67	19.96
	P	4.25	-0.94	0	-24.40	27.21	7.29
Dhamtari	A	4.92	0.11	-11.20	11.32	-1.46	58.69
	Y	5.65	-0.67	-69.62**	5.01	-55.76	11.43
	P	7.08	0.16	-12.4	14.25	18.43	31.36
Durg	A	-0.60	1.61	86.62	-5.58	-13.16	61.43
	Y	4.17	-0.20	-11.44**	-8.36	49.96	37.49
	P	7.34	-0.66	23.79**	-3.29	-60.65	30.41
Rajnandgaon	A	0.64	0.87	-23.63***	19.40	-68.92	9.75
	Y	7.25	-0.58	-16.70**	-0.09	-15.11	76.70
	P	7.96	0.26	-14.51	8.86	-18.93	37.66
Kawardha	A	0.96	1.21	36.07***	34.01	28.36	46.25
	Y	6.76	0.17	-0.17	-10.04	-29.51	63.21
	P	7.51	-0.80	-56.36**	-0.08	-99.91	48.29
Jagdalpur	A	2.08	0.09***	-11.12	0.46	-64.93	19.75
	Y	2.37	-0.77	-95.30	5.35	16.49	43.50
	P	8.96	-0.29	-61.64***	-0.23	-14.36	29.91
Kanker	A	0.92	0.77	-36.18	5.33	-31.53	76.20
	Y	2.16	-0.15	-12.22	4.23	-15.92	7.71
	P	8.45	0.291	-28.63***	-26.80	-16.34	28.03
Dantewada	A	3.45	0.41	43.38	23.72	-18.49	68.81
	Y	4.81	-0.50	-22.14***	19.89	-16.15	58.57
	P	7.96	-0.05	-88.90***	-16.62	-18.35	14.25
Bilaspur	A	4.68	-0.23**	31.94	-8.27	-50.23	26.81
	Y	1.54	-0.47	10.65	23.32	-38.20	38.92
	P	8.54	0.65	-2.38	-0.01	-1.06	28.36
Janjgir	A	1.49	0.36***	-4.39***	0.23	-1.80*	80.23
	Y	2.02	-0.24	-16.81***	0.03	-8.52	14.93
	P	6.69	1.26	-6.07	-0.10	-4.88***	23.50
Korba	A	-0.87	0.99	-2.97	0.33	-4.12	63.46
	Y	1.98	-0.07**	-1.01	1.86	4.53	35.69
	P	5.22	1.77	-2.31	0.21	-8.21**	47.35
Raigarh	A	3.39	0.28**	-8.39	0.05	-7.62	84.08
	Y	1.45	0.28	-0.11	0.05**	1.40	42.40
	P	6.75	1.14	30.26**	0.36	5.11	71.72
Jashpur	A	3.13	0.36	-6.76	-0.10	-12.81	14.57
	Y	1.24	0.92	14.94	1.72	-2.67	90.31
	P	6.21	1.26	37.74***	2.03	18.07	57.97

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

% r1 & r2 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.

Where A, Y and (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.

Results and Discussion

Partial Compound Growth Rate

Partial compound growth rate for area, production and productivity of mango was for period (2009-10 to 2013-14) presented in the table1. It was observed from the table in Chhattisgarh mango were in Raipur (29.15 per cent), Mahasamund (-21.60 per cent), Rajnandgaon (-23.63 per cent), found significant at 1% level, Kawardha (36.07 per cent) found statistically significant at 5% level.

In the case of production under mango we find that the partial compound growth rate in Durg (23.79 per cent) found statistically significant at 5% level, whereas, Jagdalpur (-61.64 per cent), Kawardha (-56.36 per cent), Kanker (-28.63 per cent), Raigarh (30.26 per cent) and Jashpur (37.74 per cent) found statistically significant at 1% level.

For the productivity of mango the partial compound growth rate in Raipur (29.22 per cent), Dantewada (-22.14 per cent), Janjgir (-16.81 per cent) found statistically significant at 1% level, Mahasamund (-66.24 per cent), Durg (-11.44 per cent) and Rajnandgaon (-16.70 per cent) had registered significant at 5% level. Koria, Sarguja Dhamtari, Jashpur, Raigarh Bilaspur, Jagdalpur had registered non significant.

Production Function of Mango

Table 2: Production function as influenced by the Area and Productivity of Mango in Chhattisgarh for Period 2009-10 to 2013-14

Districts/Region		Production Function					(1)*	(2)$	(3)@
Raipur	ln P (A, Y) = 2.47 + -0.10	ln A	+	0.094	ln Y	7.07	2.36	9.43
Mahasamund	ln P (A, Y) = 3.13 + -0.02	ln A	+	0.02	ln Y	0.04	3.26	3.26
Dhamatari	ln P (A, Y) = 2.03 + -0.05	ln A	+	0.16	ln Y	15.28	11.86	27.14
Durg	ln P (A, Y) = 2.24 + -0.13	ln A	+	0.10	ln Y	44.32	3.52	47.84
Rajnandgaon	ln P (A, Y) = 3.30 + 0.03	ln A	+	0.02	ln Y	26.40	4.68	31.08
Kawardha	ln P (A, Y) = 2.32 + 0.19	ln A	+	0.19	ln Y	25.37	14.61	39.99
Jagdalpur	ln P (A, Y) = 2.87 + -0.66	ln A	+	-0.01	ln Y	77.81	0.06	77.88
Kanker	ln P (A, Y) = 3.52 + 0.41	ln A	+	0.02	ln Y	10.63	0.21	10.85
Dantewada	ln P (A, Y) = 3.59 + 0.01	ln A	+	-0.03	ln Y	0.10	12.13	12.24
Bilaspur	ln P (A, Y) = -4.38 + -0.10	ln A	+	0.95	ln Y	0.71	4.39	5.10
Janjgir	ln P (A, Y) = -17.06 + -0.02	ln A	+	2.93	ln Y	1.50	39.12	40.63
Korba	ln P (A, Y) = -5.17 + -0.17	ln A	+	1.01	ln Y	24.13	3.81	27.94
Raigarh	ln P (A, Y) = -18.28 + -1.38	ln A	+	2.71	ln Y	43.59	16.74	60.34
Jashpur	ln P (A, Y) = -5.44 + -1.07	ln A	+	1.33	ln Y	36.20	6.01	42.21
Sarguja	ln P (A, Y) = -4.38 + -0.10	ln A	+	0.95	ln Y	0.71	4.39	5.10
Koria	ln P (A, Y) = -17.06 + -0.02	ln A	+	2.93	ln Y	1.50	39.12	40.63

* 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)

To know the extent of influence of area and productivity of mango postulated production function is given by 3 (a,b,c). Table 2. Reveled that for all the entire districts the production function satisfactorily fits to the data as indicated. This model showed highest R^2 upto 77.88 per cent for Jagdalpur district.

Conclusion

It may be included that more area and production being brought under mango in Chhattisgarh the partial compound growth rate for area in Raipur (29.15 percent), Mahasamund (-21.60 percent), Rajnandgaon (-23.637 percent), found significant at 1% level, Kawardha (36.07 percent) had found statistically significant at 5% level, and rest of districts Durg, Kanker, Raigarh, Jashpur have non-significant. The production under mango we find that the partial compound growth rate in Durg (23.79 percent) found statistically significant at 5% level, whereas, Jagdalpur (-61.64 percent), Kawardha (-52.36 percent), Kanker (-28.633 percent), Raigarh (30.26 percent) and Jashpur (37.74 percent) found statistically significant. The productivity of mango the partial compound growth rate in Raipur (29.22 percent), Dantewada (-22.14 percent), Janjgir (-16.70 percent), Raigarh (28.024 percent) are found statistically significant.

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