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Influence of area and yield on the production of cauliflower in Chhattisgarh

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Abstract
The predictive model for Cauliflower crop (*Brassica oleracea var. botrytis*) 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 partial compound growth rates of the area, production and productivity of the cauliflower have been also estimated and discussed. The productivity of cauliflower crops are expected to increase in future as prediction model has been predicted. It was observed that the compound annual growth rate of cauliflower in terms of productivity is negative during the 2009-10 to 2013-14 periods, even though the area under the cultivation of cauliflower crop and its production was positive.

Keywords: Area, production and cauliflower

Introduction
Cauliflower is a vegetables 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. 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 vegetables 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.

Materils and Mthods
The secondary data on area, production and productivity of cauliflower crops were collected for the period 2009-10 to 2013-14 from the website of www.cgnhm.gov.in The study area 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.

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 as described

$$\ln Y = \ln t + bp\ P + bt\ T + \quad ....(1a)$$

$$\text{Or } \ln = \ln t + bp\ P + bt\ T \quad ......(1b)$$

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.

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b_p = partial linear regression coefficient corresponding to variable P.

b_t = partial linear regression coefficient corresponding to variable T.

= 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, the intercept term we can have the following linear statistical model

$$P(A, Y) = c + c \ln A + c \ln Y + ' \quad \ldots\ldots (3a) \text{ or,}$$

$$P(A,Y) = c_0{}^0 + c_1{}^1 \ln A + c_2{}^2 \ln Y \quad \ldots\ldots\ldots (3b) \text{ or,}$$

$$(A,Y) = d_0 \, A^{c1} \, Y^{c2}, \quad d_0 = e^{c0} \quad \ldots\ldots\ldots\ldots (3c)$$

Where A, Y and 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.

Table 1: Prediction models (w.r.t time) of area and production under cauliflower for Chhattisgarh for period-II (2009-10 to 2013-14)

District/Region		Lnt	bp	%r1 @	Bt	% r2 @	% R²
Raipur	A	5.42	0.67	97.23**	0.30	35.70	31.38
	Y	8.11	-0.14	-13.1	-0.14	0.08	9.84
	P	8.93	0.53	71.28***	0.16	17.40	28.54
Mahasamund	A	3.57	0.76	11.43	0.17	19.12	84.21
	Y	6.18	0.54	72.26**	-0.04	-3.92	12.51
	P	6.93	0.44	55.36***	0.12	12.83	78.44
Dhamtari	A	4.77	0.46	59.52**	0.08	19.63***	83.65
	Y	9.11	-0.91	-59.96	-0.07	-7.16	59.69
	P	9.28	-0.44	-36.12**	0.013	1.33	0.30
Durg	A	5.88	1.04	18.30**	0.15	16.99	94.30
	Y	8.21	-0.42	-34.54	0.02	-82.38	19.6
	P	9.51	0.60	82.92	0.187	20.56	52.7
Rajnandgaon	A	5.51	0.45	12.64**	0.04	4.49	60.32
	Y	6.87	0.43	54.01**	-0.06	-6.22	34.55
	P	7.77	0.88	14.30**	-0.02	-1.99	78.80
Kawardha	A	5.49	0.02	2.55	0.12	13.7	43.34
	Y	6.80	0.15	16.60	-0.05	-5.30	23.18
	P	7.81	0.13	14.43	-0.09	-9.39	78.87
Jagdalpur	A	4.36	0.43	55.11	0.14	16.04	43.10
	Y	7.30	-0.00	-0.071	-0.09	-9.17	18.57
	P	9.07	-0.128	-12.03	-0.12	-12.03	25.73
Kanker	A	4.65	0.76	11.38	0.17	18.5	45.70
	Y	9.16	-1.00	-63.36	-0.06	-1.38	29.49
	P	7.71	0.67	96.85	-0.17	-15.83	40.06
Dantewada	A	4.67	-0.12	-12.10**	0.16	17.96	28.08
	Y	2.20	0.22	24.64	0.36	44.42**	8.97
	P	6.86	0.09	10.24	-0.09	-8.66	16.59
Bilaspur	A	6.86	0.15	16.99**	0.03	3.04	44.37
	Y	9.56	-0.00	-0.85	-0.01	-1.56	52.53
	P	6.52	0.59	80.65*	-0.09	-9.09	0.04
Janjgir	A	6.48	0.01	1.73	0.00	0.27	99.79
	Y	5.46	1.22	24.12	-0.12	-11.35	45.73
	P	7.13	1.32	27.43**	-0.09	-9.40	50.92
Korba	A	6.25	0.18	19.79	0.04	4.93	79.84
	Y	5.98	1.24	2.47	-0.36	-30.39	72.44
	P	7.67	1.03	18.27	-0.04	-4.5	39.82
Raigarh	A	5.68	0.33	40.10***	0.11	11.65	59.15
	Y	3.17	0.02	2.22	0.02	2.44	0.013
	P	7.60	0.73	10.81	0.09	10.05	62.80
Jashpur	A	4.75	0.6	85.83**	0.04	5.07	64.24
	Y	2.70	0.12	13.49	-0.04	-4.59	23.86
	P	7.46	0.74	11.94	0.02	0.25	47.82
Sarguja	A	5.49	0.15	16.48	0.23	26.7	37.48
	Y	1.94	0.12	13.48	0.09	10.5	31.36
	P	7.27	1.03	18.14	0.04	4.68	43.90
Koria	A	6.12	0.05	5.25	0.01	1.75	69.95

Y	2.51	0.10	10.53	0.02	2.89	8.85
P	8.64	0.15	16.34	0.04	4.69	85.19

***, **, * significant at 1%, 5% and 10% level of significant respectively @ % r1 & 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.

Results and Discussion
Partial Compound Growth Rate
It was observed from the table 1 that in Chhattisgarh as for as districts are concern the partial compound growth rate for area in Raipur (97.23 percent), Durg (18.30 percent), Rajnandgaon (12.64 percent), Dantewada(-12.10 percent), Bilaspur (16.99 percent), Dhamtari(59.52 percent) Jashpur (85.83 percent), found statistically significant at 5% level, and Raigarh (40.10) and found significant at 1% level. The Annual partial compound growth rate in area of the constitute districts we find significant result in Dhamtari (19.63 percent) at 5% level. In the case of production under cauliflower we find that the partial compound growth rate in Rajnandgaon (14.30 percent), Dhamtari (-36.12percent), Janjgir(27.43 percent) had found statistically significant at 5% level, Raipur (71.28 percent), and Mahasamund (55.36 percent) had found significant at 1% level and Bilaspur (80.65 percent) and significant at 10% level. Remaining districts are found non-significant. Annual partial compound growth rate of production in Korba (18.27 percent) had registered significant at 5% level and rest of the districts was non-significant.
For the productivity of cauliflower the periodic partial compound growth rate in Mahasamund (72.26 percent), Rajnandgaon (54.01 percent) found significant at 5% level. Raipur, Dhamtari, Kawardha, Bilaspur and other district are respectively had registered non significant result. The Annual partial compound growth rate of productivity in Dantewada (44.42 percent) had registered significant at 5% level and remaining districts were non-significant.

Production Function of Cauliflower
It was observed from the table 2 that in Chhattisgarh as for as districts are concern the production function as influenced by area, production and productivity of cauliflower district of Koria (98.35 per cent) has covered most significant under production and(83.48 per cent) with productivity. Later on Rajnandgaon (94.22 per cent) in production and (31.07pr cent) in productivity was found significant. Raipur and Dantewada districts has also found significant.

Prediction of Area, Yield and Production
Table 3 gives a prediction of area, production and productivity of fruits and vegetables crops for future five years the period 2014-15 to 2019-2020.based on the prediction model estimated in the present study. It is expected that the productivity of fruits and vegetables crops will increase by the term of this decade. We discuss the results for periods separately by using the prediction models in Table 3.

Conclusion
In case of production under cauliflower we find that the partial compound growth rate in Rajnandgaon (14.30 percent), Dhamtari(-36.21percent),Janjgir(27.43percent) had found statistically significant at 5% level, Raipur (71.28 percent), and Mahasamund (55.36 percent) had found significant at 1% level and Bilaspur (80.65 percent) and significant at 10% level.
Remaining districts are found non-significant. Annual partial compound growth rate of production in Korba (18.27 percent) had registered significant at 5% level and rests of the districts were non-significant.
For the productivity of cauliflower the periodic partial compound growth rate in Mahasamund (72.26 percent), Rajnandgaon (54.01 percent), and Durg (-36.12 percent) and found significant at 5% level. Raipur, Dhamtari, Kawardha, Bilaspur and other district are respectively had registered non significant result. The Annual partial compound growth rate of productivity in Dantewada (44.42 percent) had registered significant at 5% level and remaining districts were non-significant.

Table 2: Production function as influenced by the area and productivity of cauliflower in Chhattisgarh and its constituent districts for period II (2009-10 to 2013-14)

District	Production Function							(1)*	(2)$	(3)@
Raipur	ln P (A, Y) =	1.18	+	1.36	ln A	+	1.07	ln Y	-2.14	42.56	40.41
Mahasamund	ln P (A, Y) =	4.88	+	0.61	ln A	+	-0.02	ln Y	3.37	16.44	19.82
Dhamtari	ln P (A, Y) =	-4.60	+	1.00	ln A	+	1.00	ln Y	-10.55	6.73	6.60
Durg	ln P (A, Y) =	-4.83	+	1.00	ln A	+	1.00	ln Y	18.17	-2.62	-2.44
Rajnandgaon	ln P (A, Y) =	-4.60	+	0.99	ln A	+	1.00	ln Y	-21.65	31.07	94.22
Kawardha	ln P (A, Y) =	-3.64	+	0.96	ln A	+	0.90	ln Y	24.65	59.10	6.15
Jagdalpur	ln P (A, Y) =	-4.59	+	0.99	ln A	+	0.98	ln Y	14.33	95.30	10.96
Kanker	ln P (A, Y) =	4.13	+	0.53	ln A	+	0.20	ln Y	-4.22	22.56	2.21
Dantewada	ln P (A, Y) =	-0.05	+	0.99	ln A	+	1.02	ln Y	-60.67	65.49	59.47
Bilaspur	ln P (A, Y) =	-10.17	+	2.45	ln A	+	0.35	ln Y	0.09	2.02	2.26
Janjgir	ln P (A, Y) =	-51.81	+	8.28	ln A	+	0.95	ln Y	13.05	10.89	12.20
Korba	ln P (A, Y) =	-6.77	+	1.81	ln A	+	0.55	ln Y	29.91	1.30	1.60
Raigarh	ln P (A, Y) =	2.55	+	0.91	ln A	+	0.14	ln Y	7.66	3.97	4.74
Jashpur	ln P (A, Y) =	0.001	+	1.00	ln A	+	0.99	ln Y	2.14	-8.39	1.30
Sarguja	ln P (A, Y) =	8.11	+	0.19	ln A	+	-0.16	ln Y	15.93	-2.48	-23.26
Koria	ln P (A, Y) =	0.022	+	0.99	ln A	+	1.00	ln Y	14.89	83.45	98.35

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, yield and production under Cauliflower in Chhattisgarh for 2014-15 to 2019-20

Districts / Year		2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Raipur	A	70262	95320	129314	175430	237993	138551
	Y	95.24	97.98	99.81	105.78	110.02	117.98
	P	661324	776071	910728	106875	125418	113257
Mahasamund	A	18398	21807	25848	30638	36315	39340
	Y	34.89	35.43	38.96	39.03	39.62	54.14
	P	38948	43914	49513	55826	62943	60475
Dhamtari	A	5100	5563	6069	6620	7222	8078
	Y	5.81	5.41	5.55	6.71	7.39	8.33
	P	321454	325745	328855	334848	338975	407810
Durg	A	17168	26696	23454	274147	32042	485733
	Y	13.11	14.85	18.54	19.34	20.25	21.22
	P	2024844	244119	294317	354837	427801	370058
Rajnand gaon	A	9877	10280	10700	11136	11591	15584
	Y	28.28	28.49	28.99	29.56	47.84	47.55
	P	2649854	2597344	2545913	2495501	2446087	6388436
Kawardha	A	3234	3679	41852	47672	54558	32994
	Y	35.57	67.28	65.73	40.60	31.57	34.46
	P	637444	582549	532410	486861	444706	725901
Jagdalpur	A	3016	3498	4056	4703	5453	4675
	Y	12.64	19.74	19.45	20.66	24.52	31.75
	P	27625	24385	21388	18818	16557	24305
Kanker	A	5417	64215	76114	90219	106937	115844
	Y	3.04	2.82	2.66	2.50	2.36	1.10
	P	400312	337729	284935	240384	202805	782305
Dantewada	A	47.94	56.26	66.02	77.47	90.92	42.52
	Y	15.16	17.77	14.45	21.40	31.34	33.69
	P	18937	17305	15817	14457	13208	20854
Bilaspur	A	3422	3526	3633	3744	3858	3999
	Y	44.69	44.95	66.59	69.61	93.99	44.69
	P	70122	64087	58571	53530	48922	126626
Janjgir	A	74897	75099	75302	75506	75710	76181
	Y	38.20	33.88	35.63	57.61	64.31	65.63
	P	440131	402250	367629	335987	307069	12650
Korba	A	2293	2406	2525	2649	2779	2746
	Y	57.92	40.40	28.19	19.66	13.72	20.09
	P	83853	80565	77406	74371	71455	23703
Raigarh	A	4582	5115	5710	6374	7115	6374
	Y	28.84	29.54	30.26	31.00	31.75	29.45
	P	77374	85085	93565	102889	113143	161041
Jashpur	A	14617	15214	15835	16481	17154	26635
	Y	37.33	35.87	34.46	33.11	31.81	42.09
	P	64822	64952	65082	65213	65343	13586
Surguja	A	10284	12944	16297	20504	25814	11974
	Y	20.86	22.82	24.97	27.33	29.90	23.66
	P	585028	608903	633753	659617	686536	164526
Koria	A	690	702	714	726	738	725
	Y	28.16	28.96	29.78	30.63	31.50	31.12
	P	19633	20537	21482	22471	23505	22811

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