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Research Article

ESTIMATED MODELS FOR THE AREA, PRODUCTION AND YIELD OF RAPESEED-MUSTARD IN CHHATTISGARH AND ITS CONSTITUENTS DISTRICTS

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Abstract- Rapeseed-Mustard is the second most important edible oil seed crop in India after groundnut and occupies country's oilseed production nearly 30%. The present investigation aimed to estimation of predictive models for the Rapeseed-Mustard 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 Rapeseed-mustard have been made year wise between 1998-99 to 2013-14. The productivity of Rapeseed-mustard in Chhattisgarh plain is expected to decrease from 396 to 334 kg/ha by the turns of one decades, if it presents growth trends is decreased than it reveals that the major projected implementation should be adopted for increase the yield of oilseed crops in this state. 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 in Dhamtari, Durg, Rajnandgaon, Bilaspur and Janjgir district's area influences the production of Rapeseed-Mustard by more than 42 percent. For the district, Mahasamund and Korba production was influenced by the productivity and only a little contribution is made by the area.

Keywords- Partial compound growth rate, Prediction models, Production function, Rapeseed-Mustard, Oilseed.

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Introduction

Among the Rapeseed-Mustard growing countries in the world India plays a major role. With regarding rapeseed-mustard India ranks first in area and second in production. Rapeseed-Mustard is the second most important edible oil seed crop in India after groundnut and occupies country's oilseed production nearly 30%. Madhya Pradesh (including Chhattisgarh), Rajasthan, Maharashtra, Gujarat, Andhra Pradesh, and Karnataka states are major contributors in India. These states consist about 86% area under and 84% production of oilseed crops. The soybean ranks first with 29.57% to total oilseeds production followed by rapeseed-mustard (29.06%), groundnut (28.57%) and sunflower (5.14%). Soybean, rapeseed-mustard and groundnut are the important crops, which together account 87.2% of the total oilseeds production of India. The annual production during 2009-10 was around 8.67 million tonnes. Among the different states in our country Rajasthan was leading followed by Uttar Pradesh, Haryana, Madhya Pradesh, Gujarat, West Bengal, Bihar and Punjab etc.

Chhattisgarh state occupied by 51.7(000' hectare), area 4.0(000' tonnes) production and 379(kg/hec) yield in year 2008-09. This state consist three agro climatic Zones, namely- Chhattisgarh Plain, Baster Plateau, and Northern Hills. Chhattisgarh Plain had the highest area (130.07 thousand hectare) and production (107.56 thousand M.T.) which is 62.03% and 82.36% respectively to the total area and production of oil seed in the state. Being predominantly tribal, Chhattisgarh had been drawing continuous attention of governmental agencies to improve the scenario of crop production. The planners are still not sure of the position of production that will be in the coming year and that of its contributing factors i.e. area and productivity. To depict the complete scenario the present study aims at collecting and maintaining a relational database of area, production and productivity of rapeseed-mustard crop in different districts of Chhattisgarh plain zone. Using these data, to develop reliable predictive models for the area, production and productivity of groundnut for Chhattisgarh Plain and its constituent districts. Production function had also been developed to know the extent of influence of area and productivity on production [1].

MaterialsandMethods

The secondary data on area, productivity and production of Rapeseed-Mustard crop were collected for the period 1998-99 to 2013-14 from the "Agricultural statistics" published by the Directorate of agriculture, Government of Madhya Pradesh [2, 3] and [10]. 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 analysis it was realized that a five year periodic effect is working on the response variable in most of the district/regions. Therefore, this periodic effect was productivity scenario of rice probably due to some research or technical break-through, etc. Thus, the technique of "Tests of structural change" and "Dummy Variables" were used as described in [5,6].After fitting such structural /periodic effects, *i.e.*, (α's), it was found in most cases that they were showing a trend over the four periods in almost all districts and slops (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 within each period. So, the following multiple regression models was finalized and fitted in all cases using stepwise regression technique as described in [5].

$\ln Y = Int + b_pP + b_tT + \epsilon$ .... [Eq-1a]

Or $\hat{\ln} Y = Int + b_pP + b_tT$ .... [Eq-1b]

Where, $\widehat{\ln} Y$ = expected value of the natural logarithm of the response variable Y may be area, productivity or production of a given district/ region;

Int = intercept; P= periodic time Variable .

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

b_p = partial linear regression coefficient corresponding to variable P;

b_t= partial linear regression coefficient corresponding to variable T;

$\in$ = error/disturbance component normally distributed with mean zero and common varianceσ^2, i.e. $\in \sim (0,\sigma^2)$.

Let T be fixed at a particular position in any period, i.e. at 1st, 2nd or 3rd etc. so that it may be considered constant within any period while P varies. Then we may write [Eq-1b] in the form

$\widehat{\ln} Y = C + bp\, P$, where C = Int (since bt= 0 for constant T) .... [Eq-2a]

or, $Y_x = ae^{\theta X}$, where Yx = Y, a= e^c , $\theta = b_p$, x=P .... [Eq-2b]

On putting x= 0 and 1 respectively in equation (2b), we get 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 Rapeseed-Mustard]. For that we need 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 component by $\in' \sim N(0,\sigma^2_{\in'})$ and then introducing the intercept term we can have the following linear statistical model

$\widehat{\ln} P\,(A, Y) = c_0 + c_1 \ln A + c_2 \ln Y + \in'$ ....[Eq-3a]

or, $\widehat{\ln}\, P\,(A,Y) = c_0 + c_1 \ln A + c_2 \ln Y$ ....[Eq-3b]

or, $\hat{P}\,(A,Y) = d_0\, A^{c_1}\, Y^{c_2}$, $d_0 = e^{c_0}$ ....[Eq-3c]

Where A, Y and $\hat{P}$ (A, P) denoted the area, productivity and estimated production of a given region. The constant c0 is the intercept and (c_1, c_2) are the partial regression coefficients corresponding to variables lnA and lnY respectively[1,4,9].

Results and Discussion

Prediction models and partial compound growth rates of area, production and productivity

Partial compound growth rate of area, production and yield of Rapeseed-Mustard was for period (1998-99 to 2012-13) and presented in [Table-1].

Table-1 *Prediction models of area, productivity and production under Rapeseed-Mustard for Chhattisgarh plain zone and its constituent districts for period*

District/Region		Int	b_p	%r_1 @	b_t	% r_2 @	% R^2
Raipur	A	-0.240	0.230**	(25.855)**	-0.016	-1.591	39.049**
	Y	6.141	-0.031	-3.037	-0.028	-2.764	4.893
	P	-1.043	0.206*	(22.885)*	-0.038	-3.760	23.942*
Mahasamund	A	-2.064	0.047	4.857	-0.004	-0.374	1.161
	Y	6.236	-0.111	-10.489	0.000	0.037	8.156
	P	-2.435	-0.132	-12.356	-0.042	-4.096	4.376
Dhamtari	A	-0.729	0.772***	(116.404)***	-0.017	-1.669	43.383***
	Y	6.261	-0.034	-3.307	-0.032	-3.140	6.682
	P	-1.450	0.755***	(112.755)***	-0.039	-3.796	53.404***
Durg	A	-1.775	0.756***	(113.011)***	0.138	14.844	75.585***
	Y	6.204	-0.063	-6.111	-0.050	-4.912	12.743
	P	-2.530	0.706***	(102.674)***	0.093	9.754	79.960***
Rajnandgaon	A	0.142	-0.223***	(-20.022)***	-0.100	-9.523	90.120***
	Y	6.181	-0.058**	(-5.594)**	-0.030	-2.927	9.972**
	P	-0.616	-0.274**	(-23.946)**	-0.126*	(-11.797)*	65.496**
Kawardha	A	1.076	-0.060	-5.831	-0.067*	(-6.470)*	29.005
	Y	6.156	-0.0621	-6.025	-0.025	-2.500	9.342
	P	0.302	-0.117	-11.069	-0.090	-8.565	23.124
Bilaspur	A	1.141	-0.127***	(-11.882)***	-0.023	-2.241	58.800***
	Y	6.180	-0.042	-4.122	-0.046	-4.529	9.008
	P	0.310	-0.146*	(-13.548)*	-0.055	-5.352	34.656*
Janjgir	A	-1.735	0.747***	(111.130)***	0.059	6.097	57.401***
	Y	6.153	-0.033	-3.236	-0.041	-3.964	7.449
	P	-2.448	0.703***	(101.913)***	0.015	1.500	64.325***
Korba	A	0.805	-0.008	-0.836	-0.004	-0.375	2.545
	Y	6.189	-0.092	-8.791	-0.050	-4.858	18.481
	P	0.078	-0.097	-9.251	-0.054	-5.221	21.502
Raigarh	A	-0.697	0.375***	(45.425)***	0.050	5.085	54.920***
	Y	6.195	-0.032	-3.156	-0.031	-3.075	8.055
	P	-1.334	0.323***	(38.142)***	0.011	1.073	52.524***
Plain Zone	A	2.403	0.191***	(21.086)***	-0.022	-2.180	45.143***
	Y	6.148	-0.033	-3.277	-0.034	-3.348	7.923
	P	1.643	0.158**	(17.118)**	-0.056	-5.456	45.518**

*significant at 10% level, ** significant at 5% level, *** significant at 1% level

@% r_1 and @%r_2 indicate the partial compound growth rates (in percentages) corresponding to b_p and b_t respectively

A: Area in 000' ha, Y: Yield in Kg/ha, P: Production in 000' tones

It was observed that from the [Table-1] Chhattisgarh plain had significant periodic partial compound growth rate in area (21.086 percent) and production (17.118 percent) and found statistically significant at 5 percent and 10 percent respectively. Whereas the annual partial compound growth rate found to be statistically non-significant for area, production and productivity of rapeseed-mustard.

For Area the periodic partial compound growth rate in Dhamtari (116.404 percent), Durg (113.011 percent), Rajnandgaon (-20.022 percent), Bilaspur (-11.882 percent), Janjgir (111.130 percent) and Raigarh (45.425 percent) were found statistically significant at 1 percent level, whereas Raipur (25.855 percent) was found statistically significant at 5 percent level. Highest periodic partial compound rate of change was recorded in Dhamtari (116.404 percent) and the lowest growth rate found in Korba (-0.836 percent). The annual partial compound growth rate for area of the constituents district Kawardha (-6.470 percent) was found statistically significant at 10 percent level. Highest annual rate of change recorded in Durg (14.844 percent) and lowest rate of change recorded in Mahasamund (-0.374 percent). It is observed that periodic partial compound growth rate of production in Dhamtari (112.755 percent), Janjgir (101.913 percent), and Raigarh (38.142 percent) were found statistically significant at 1 percent level, whereas in Rajnandgaon (-23.946 percent) at 5 percent level and Raipur (22.885 percent), Bilaspur (-13.548 percent) were found statistically significant at 10 % level. The annual partial compound growth rate for production, only district Rajnandgaon (-11.797 percent) was found statistically significant at 10 percent level. Highest annual partial periodic growth rate recorded in Rajnandgaon (-11.797 percent) and lowest in Janjgir (1.500 percent).For yield under rapeseed-mustard for the district only Rajnandgaon (-5.594 percent) only was registered significant at 5 percent level and the remaining districts were registered non-significant results. Highest periodic partial compound growth rate had recorded in Mahasamund (-10.489 percent) and the lowest in Raipur (-3.037 percent), whereas annual partial compound growth rate all districts were found statistically non-significant.

Production Function

To know the extent of influence of area and productivity on the production of Rapeseed-Mustard the postulated production function is given by equations [Eq-3a], [Eq-3b] and [Eq-3c]. The estimated production in terms of area and yield for the period has been presented in [Table-2]. For Durg and Rajnandgaon districts the production function satisfactorily fits to the data as indicated by more than 70 percent. The model showed highest R^2 up to 82.05 percent for Rajnandgaon district. The column (1) and (2) showed that in Dhamtari, Durg, Rajnandgaon, Bilaspur and Janjgir district's area influences the production of rapeseed-mustard by more than 42 percent. For the district Mahasamund and Korba area contributes less production when compared to the productivity [1, 9].

Table -2 *Production function as influenced by the area and productivity of Rapeseed- Mustard in Chhattisgarh plain and its constituent districts for period*

District/Region	Production Function								(1)*	(2)$	(3)@
Raipur	ln P (A, Y) =	4.3002	+	0.2886	ln A	-	0.1717	ln Y	30.834	5.397	36.230
Mahasamund	ln P (A, Y) =	4.5958	+	0.0798	ln A	-	0.1858	ln Y	0.560	12.868	13.428
Dhamatari	ln P (A, Y) =	1.5883	+	0.1454	ln A	+	0.2658	ln Y	42.753	6.530	49.283
Durg	ln P (A, Y) =	2.6318	+	0.2063	ln A	+	0.1108	ln Y	78.970	2.201	81.171
Rajnandgaon	ln P (A, Y) =	3.0920	-	0.5785	ln A	-	0.0204	ln Y	81.991	0.059	82.051
Kawardha	ln P (A, Y) =	4.5091	-	0.2551	ln A	-	0.1673	ln Y	16.930	3.882	20.812
Bilaspur	ln P (A, Y) =	5.5119	-	0.8886	ln A	-	0.2457	ln Y	54.939	14.571	69.510
Janjgir	ln P (A, Y) =	2.5387	+	0.1690	ln A	+	0.1328	ln Y	60.666	2.909	63.575
Korba	ln P (A, Y) =	5.5419	-	0.5920	ln A	-	0.3009	ln Y	2.540	20.883	23.423
Raigarh	ln P (A, Y) =	2.6850	+	0.3049	ln A	+	0.0951	ln Y	59.552	0.943	60.495
Plain zone	ln P (A, Y) =	1.9860	+	0.4192	ln A	+	0.0325	ln Y	37.678	0.128	37.806

* 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 [Eq-3]

Prediction of area, yield and production for 2014-15 to 2022-23:

[Table-3] gives a prediction of area, yield and production of Rapeseed-Mustard for the future years of 2014-15 to 2022-23 based on the prediction models estimated in the present study [Table-1] [1, 7, 8]. It is expected that the productivity of groundnut in Chhattisgarh plain will decrease from 396 to 334 kg/hec, {((334-396)/396)100 = -15.66%}, by the turn of one decade, if the present growth trend in productivity has same. Since the increasing in area is going to be {((25.77-23.24)/23.24)100 = 10.89%}, the -15.66 % rate of decreases in productivity is going to be inadequate to cater to the oil 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-1].

Conclusion

It may be concluded that more area are being brought under Rapeseed-Mustard in Chhattisgarh plain at a significant periodic partial compound growth rate of 21.086 percent after fifth year and within each fixed period at a non-significant annual partial compound growth rate. Accept Rajnandgaon all plain zone and its constituent's districts have non-significant trends in yield, indicating a lack of impact of new technologies in these areas. The production is more influenced by the yield (60-80%) than by the area. Therefore, area demands more attention than yield. By the turn of one decade, the increase in area and decrease in productivity under Rapeseed-Mustard is going to be (10.89% and -15.66% per annum respectively) compared to the oil requirement of ever-increasing population. Hence, to improve the productivity at much faster rate we need to identify the gaps and constraints and adopt the new improved technologies.

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Table-3 *Prediction of area, yield and production for 2014-15 to 2022-23 using* [Table-1]

DISTRICT/REGION		YEAR									
		2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Raipur	A	1.9416	1.9107	1.8803	1.8503	1.8209	2.4435	2.4047	2.3664	2.3287	2.2917
	Y	399	388	377	367	357	387	376	366	356	346
	P	0.7737	0.7446	0.7166	0.6897	0.6638	0.9508	0.9150	0.8806	0.8475	0.8157
Mahasamund	A	0.1528	0.1523	0.1517	0.1511	0.1506	0.1603	0.1597	0.1591	0.1585	0.1579
	Y	328	328	328	329	329	294	294	294	294	294
	P	0.0496	0.0475	0.0456	0.0437	0.0419	0.0434	0.0417	0.0399	0.0383	0.0367
Dhamtari	A	10.4024	10.2288	10.0580	9.8902	9.7251	22.5113	22.1355	21.7660	21.4027	21.0455
	Y	444	430	416	403	390	429	415	402	390	378
	P	4.6252	4.4496	4.2807	4.1183	3.9619	9.8404	9.4669	9.1075	8.7618	8.4292
Durg	A	4.0064	4.6011	5.2842	6.0686	6.9694	8.5341	9.8010	11.2558	12.9267	14.8456
	Y	366	348	331	314	299	343	326	310	295	281
	P	1.4751	1.6190	1.7769	1.9503	2.1405	2.9897	3.2813	3.6014	3.9526	4.3382
Rajnandgaon	A	0.4266	0.3859	0.3492	0.3159	0.2858	0.3412	0.3087	0.2793	0.2527	0.2286
	Y	373	362	351	341	331	352	342	332	322	312
	P	0.1594	0.1406	0.1240	0.1094	0.0965	0.1212	0.1069	0.0943	0.0832	0.0734
Kawardha	A	2.1570	2.0174	1.8869	1.7648	1.6507	2.0312	1.8998	1.7769	1.6619	1.5544
	Y	359	350	341	332	324	337	329	320	312	305
	P	0.7738	0.7076	0.6470	0.5915	0.5409	0.6882	0.6292	0.5753	0.5261	0.4810
Bilaspur	A	1.8440	1.8027	1.7623	1.7228	1.6842	1.6249	1.5885	1.5529	1.5181	1.4841
	Y	390	372	355	339	324	374	357	341	325	310
	P	0.7207	0.6822	0.6456	0.6111	0.5784	0.6231	0.5897	0.5582	0.5283	0.5000
Janjgir	A	3.7174	3.9441	4.1845	4.4396	4.7103	7.8486	8.3271	8.8348	9.3734	9.9449
	Y	396	380	365	351	337	383	368	353	339	326
	P	1.4590	1.4809	1.5031	1.5257	1.5486	2.9460	2.9902	3.0350	3.0806	3.1268
Korba	A	2.1547	2.1467	2.1386	2.1306	2.1226	2.1367	2.1287	2.1207	2.1128	2.1049
	Y	321	305	291	276	263	293	279	265	252	240
	P	0.6946	0.6583	0.6239	0.5914	0.5605	0.6303	0.5974	0.5662	0.5367	0.5086
Raigarh	A	2.3411	2.4601	2.5852	2.7167	2.8548	3.4045	3.5776	3.7595	3.9507	4.1516
	Y	418	405	393	381	369	405	392	380	369	357
	P	0.9693	0.9797	0.9902	1.0008	1.0115	1.3390	1.3533	1.3679	1.3825	1.3974
Plain Zone	A	23.2444	22.7376	22.2419	21.7570	21.2827	28.1458	27.5321	26.9319	26.3447	25.7704
	Y	396	382	370	357	345	383	370	358	346	334
	P	9.1973	8.6956	8.2212	7.7727	7.3486	10.7717	10.1841	9.6285	9.1032	8.6066