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Komal Chawla
Student M.Sc. (Ag. Statistics), Department of Agricultural Statistics, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Vikas Kumar
Student M.Sc. (Ag. Statistics), Department of Agricultural Statistics, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Dr. AK Singh
Professor and Head, Department of Agricultural Statistics, IGKV, Raipur, Chhattisgarh, India

Corresponding Author:
Komal Chawla
Student M.Sc. (Ag. Statistics), Department of Agricultural Statistics, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Predictive model and productions function for area, production and productivity of rapeseed and mustard crop in Bastar plateau agro climatic zone of Chhattisgarh

Komal Chawla, Vikas Kumar and Dr. AK Singh

Abstract
Chhattisgarh State has three agro climatic zones, Chhattisgarh Plains, Bastar plateau and Northern Hills Region. In the present study, an attempt has made to study the predictive models and production function for area, production and productivity of Rapeseed and Mustard crop in Bastar plateau agro-climatic zone of Chhattisgarh. Time series data for the period from 1983-84 to 2010-11 on Rapeseed and Mustard were utilized for the study. The predictive model under study included a unique feature of structural periodic effect as a factor to capture the cyclic pattern, if any, along with trend effect in the time-series data. This periodic effect was estimated for area, production and productivity of the Rapeseed and Mustard. Apart from this model as a first case, wherein 4-year periodic cyclic effect is assumed along with annual effect working within it as a nested effect; another model has also been assumed with an overall periodic effect variable in combination with overall trend effect variable without any nesting, for comparison with the first case. Additionally, influences of area and productivity of the crops were also worked out to understand the impact of influencing factor (either area or productivity) on the production of Rapeseed and Mustard.

Keywords: Rapeseed and Mustard, area, production, productivity, predictive model, production function

Introduction
Chhattisgarh State has three agro climatic zones, Chhattisgarh Plains, Bastar plateau and Northern Hills Region. The plateau region comprises of Bastar, Dantewada, Kanker, Narayanpur, Bijapur, Kondagaon and Sukma. The Bastar plateau has undergone two divisions in 1998-99 and 2006-07. However, in the present study all the divisions of erstwhile Bastar plateau have been amalgamated to study area, production and productivity of Rapeseed and Mustard crop in Bastar plateau region of Chhattisgarh. The time series secondary data were collected for these parameters from 1983-84 to 2010-11.
Predictive model proposed by Singh and Baghel (1991-94) has been fitted separately for area, production and productivity for Bastar plateau region in addition to assessment of their growth rates. Predictions were also made for the next 8 years wherever model diagnostics permitted.
Apart from above a production function was also estimated to understand the influences of area and productivity on the production of the Rapeseed and Mustard crop in the entire Bastar plateau during this period.
Thus, the objective of present study is (i) to develop predictive models for area, production and productivity of Rapeseed and Mustard crop for Bastar plateau region, (ii) to assess growth rate of area, production and productivity of Rapeseed and Mustard crop for Bastar plateau region and (iii) to assess the influencing factor (area and productivity) on production of Rapeseed and Mustard crop for Bastar plateau region.

Material and Methods
The required time series data for the study were collected from various publications of Agricultural Statistics (1980-81 to 1997-1998) and from the website www.agridept.cg.gov.in/agriculture/kharif.htn (1998-99 to 2010-11).
A prediction model was hypothesized as proposed by Singh and Baghel (1991-94), assuming a periodic effect present in the data for a given response variable for a given region. The predictive model included a unique feature of structural periodic effect as a factor to capture the cyclic pattern, if any, along with trend effect in the time-series data. This periodic effect was estimated for area, production and productivity of the Rapeseed and Mustard crop

where in, 4-year periodic cyclic effect as a factor was assumed along with annual effect within these periodic effects; another model was also assumed with an overall periodic variable, *without assuming cyclic effect*, in combination with overall trend effect, for comparison with the first case and for prediction. Thus, the following predictive model was fitted using step-wise regression technique as per Draper and Smith (1981).

$\ln Y = Int + b_P P + b_{t(p)} T + \varepsilon$ …… (1a)
$\hat{\ln} Y = Int + b_P P + b_{t(p)} T$ ……..…….... (1b)

Where, $\hat{\ln} Y$= expected value of the natural logarithm of the response variable; Y: area, productivity (*i.e.*, yield) or production of given a region; Int = intercept; P = periodic time variable taking values from 1 to 7 signifying Period-1, i.e., first period for 1983-84 to 1986-87; Period-2, i.e., second period for 1987-88 to 1990-91; Period-3, i.e., third period for 1991-92 to 1994-95; Period-4, i.e., fourth period for 1995-96 to 1998-99; Period-5, i.e., fifth period for1999-2000 to 2002-03; Period-6, i.e., sixth period for 2004-05 to 2007-08; Period-7, i.e., seventh period for 2007-08 to 2010-11; T= annual time variable taking values from 1 to 4 signifying the 1st, 2nd, 3rd or 4th year nested within each of periods 1 to 7; b_P= partial linear regression coefficient corresponding to variable P; $b_{t(p)}$ = partial linear regression coefficient corresponding to variable T nested within different periods; ε = error/disturbance component.

Apart from fitting above model as a first case, another model has also been fitted with a little deviation of assuming only an overall periodic variable, *without cyclic effect*, in combination with overall trend effect, for comparison with the first case, as well as for the prediction, because dummy value, otherwise in the former case, is difficult to be assigned any value with confidence for future case, *due to its being a factor (not taking any numerical value)*.

The growth rates can be estimated from the aforesaid equation (1b) only as follows. Let T be fixed at a particular position in any period, say at 1st, 2nd or 3rd etc. so that it may be considered constant within any period while P varies. Then we may write (1b) in the form.

$\hat{\ln} Y = C + b_P P$, where C = Int (since $b_{t(p)} = 0$ for constant T) ……(2a)
Or, $Y_x = a\, e^{\theta x}$, where $Y_x = Y$, $a = e^c$, $0 = b_p$, $x = P$ …….. (2b)

Again, on putting x=0 and 1 respectively we get $Y_0 = a$ and $Y_1 = a\, e^{\theta} = Y_0 (1+r_1)$, 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, $r_1 = e^{\theta} - 1 \approx 1 + \theta - 1 = \theta = b_p$ (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 $\%r_2 = \{(Y_{t(p)} - Y_{t(p)-1})/ Y_{t(p)-1}\}100$ and $b_{t(p)}$ were interpreted with respect to variable T.

Lastly, our interest was to find the extent of influence of area and productivity on the production of oilseeds in Bastar plateau agro-climatic zone of Chhattisgarh. For this, an additive model with an error term $\varepsilon \sim N(0, \sigma^2)$ was hypothesized, of course, subject to the subsequent diagnostic tests. Since we have an identity, namely, "Production= Area × Productivity", in actual practice the area, production and productivity are not always reported to be accurate enough to give above identity, due to probably rounding errors and many a times due to human error in recording the data. Therefore, assuming that the error term is approximately some powers of discrepancies in the reported data compared to actual area, production and productivity; this identity could be written in the functional form. Thus, after taking natural logarithms, denoting the error component by $\varepsilon' \sim N(0, \sigma^2)$ and then by introducing the intercept term the following linear statistical model have been obtained:

$\ln P(A,Y) = c_0 + c_1 \ln A + c_2 \ln Y + \varepsilon$ …… (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)

where A, Y and $\hat{P}(A,Y)$ 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 In A and In Y influencing the production, assuming that $\epsilon \sim N(0, \sigma^2)$.

Result and Discussion

Predictive models and partial growth rates

The predictive model-1 and model-2 along with their estimated regression coefficients for periodic and annual effects/growth rates for area, production and productivity are shown in Table A-1 of Appendix-A. Thus, it is evident from Table A-1, that the estimated predictive models as defined in equations 1(a) and 1(b) for area, production and productivity under Rapeseed and Mustard crop in Bastar plateau region were highly significant for model-1 with respective R^2 77.34%, 83.72% and 81.3% ($P \leq 0.05$), and for model-2 with respective R^2 46.29%, 41.54% and 44.49%, ($P \leq 0.05$). For area under Rapeseed and Mustard, model-1, the regression coefficients which were found to be significant is for periodic effect period-7 and annual effect/growth rate for Year-7 (48.02%, $P<0.05$), on the contrary, for model-2 both the periodic effect and annual effect/growth rate were found to be non-significant. For production under Rapeseed and Mustard, model-1, the regression coefficients which were found to be significant are for periodic effects period-5 and period-7 and annual effects/growth rates for Year-5 and Year-7 (-45.08% and 47.21%, $P \leq 0.05$) whereas for model-2, both the periodic effect and annual effect/growth rate were found to be non-significant. In the same way, for productivity under Rapeseed and Mustard, model-1, the regression coefficients which were found to be significant are for periodic effects period-5 and annual effects/growth rates for Year-5 (-37.38%, $P<0.05$). Similarly, for model-2 both the periodic effect and annual effect/growth rate were found to be significant with year effect (-0.846%).

The diagnostic plots are given in Appendix-B. From the diagnostic plots of the model-1 given in Fig.B.1 to Fig.B.6, it is evident that the predictive models are good enough for area, good enough for production and good enough for productivity in which case a quadratic fit based on time series variable and taking care of outliers may improve the model.

Prediction of area, production and productivity for next 8 years

The predictions for area, production and productivity of Bastar plateau region along with the standard errors and confidence intervals are given in tables Table A-2 to Table A-4 of Appendix-A, and depicted graphically from Fig.B.8 to Fig. B.10 in the Appendix-B, on whose perusal it is clear that, the expected area after 8 years under Rapeseed and Mustard would increase from 2.092 log 000'ha, (i.e. 8.105 000'ha approx) in 2011-12 to 2.310 log 000'ha, (i.e. 10.097 000'ha

approx) in 2018-19, the expected production would decrease from 0.881 log(000'tonnes), (i.e. 2.412 (000'tonnes) approx) in 2011-12 to 0.532 log(000'tonnes), (i.e. 1.703 (000'tonnes) approx) in 2018-19 after 8 years and the expected productivity would decrease from 5.703 log(kg/ha), (i.e. 299.772 (kg/ha) approx) in 2011-12 to 5.141 log(kg/ha). (i.e. 170.848 (kg/ha) approx) in 2018-19 after 8 years. From figures Fig. B.7 to B.9, it is evident that the predictions for area, production and productivity are good enough from 2011-12 to 2014-15, beyond which the confidence interval widens, as is expected because the extrapolated predictions of regression models are valid within a close range only.

Production function

The production function equations are given in 3(a), 3(b) and 3(c). The coefficients of determination R^2 (Adj-R^2), as shown in Table A-5 of the Appendix-A, for the production function is 99.71*** (99.69***), with significant regression coefficients 0.994*** (P<0.001) and 1.003*** (P<0.001) respectively corresponding to area and productivity components. From the diagnostic plot given in the figure Fig B.10 of Appendix-B, it is moderately a good model fit (i.e. a robust fit). The influence of area and productivity on production has been determined from this production function and the estimated influence of area and productivity has been given in Table A-5. It was found for Bastar plateau that, the area has significantly contributed towards production of Rapeseed and Mustard in Bastar plateau to the extent of 78.68% (P<0.01) and the yield effect has not much influence on production (only 21.02%, P<0.01). This shows that there is lack of awareness among farmers of Rapeseed and Mustard with respect to use of technology in Rapeseed and Mustard production in Bastar plateau.

Appendix-A (Tables)

Table A-1: Estimated prediction models for area, production and productivity of bastar plateau under rapeseed and mustard for period 1, Period 2, Period 3, Period 4, Period 5, Period 6 and Period 7 (Bastar Plateau: 1983-84 to 2010-11)@

Bastar:		$b_p(\%r_1)$							$b_t(\%r_2)$							%R^2	%Adj R^2	Remark
		Int	Period2	Period3	Period4	Period5	Period6	Period7	Year1	Year2	Year3	Year4	Year5	Year6	Year7			
A	(1)$	15.49	41.51	98.52	77.75	175.8	16.78	-978.2*	-0.006	-0.027	-0.055	-0.045	-0.094	-0.015	0.480**	77.34*	56.29	P7,Y7
	(2)	3.204***	-11.538						0.0056							46.29***	41.99	I
P	(1)$	187.700	-203.300	45.760	-73.030	715.90#	-32.320	-1135*	-0.094	0.009	-0.116	-0.056	-0.451**	-0.077	0.472**	83.72**	68.6	P5,P7,Y5,Y7
	(2)	2.235***	5.542						-0.0028							41.54**	36.86	I
Y	(1)$	179.000	-244.800	-51.000	-147.900	575.300*	-50.260	-164.300	-0.087	0.036	-0.061	-0.012	-0.374***	-0.061	-0.004	81.3**	63.94	P5,Y5
	(2)	5.937***	16.991**						-0.0084**							44.49***	40.05	I

Note : Significance codes- 0 '***' 0.001 '**' 0.01 '*' 0.05 '#' 0.1 ' ' 1 ; $ Row(1) indicates estimates with structural periods while Row(2) indicates estimates assuming non-structural periods; @ Periodicity of different periods: 04 years

Table A-2: Prediction of area for bastar plateau under rapeseed and mustard for next 8 years

Year	Predicted log (Area) Log (000'ha)	Log(S.E.) log(000'ha)	Confidence Interval (95%) log(000'ha)		Predicted Area (000'ha)
			Lower limit	Upper limit	
2011-12	2.092	0.195	1.690	2.495	8.105
2012-13	2.138	0.220	1.684	2.591	8.481
2013-14	2.183	0.247	1.675	2.691	8.874
2014-15	2.228	0.274	1.664	2.793	9.285
2015-16	2.157	0.324	1.490	2.825	8.649
2016-17	2.208	0.356	1.475	2.942	9.102
2017-18	2.259	0.389	1.459	3.060	9.578
2018-19	2.310	0.422	1.442	3.179	10.079

Table A-3: Prediction of production for bastar plateau under rapeseed and mustard for next 8 years

Year	Predicted log(Production) (000'tonnes)	Log(S.E.) log(000'tonnes)	Confidence Interval (95%) log(000'tonnes)		Predicted Production (000'tonnes)
			Lower limit	Upper limit	
2011-12	0.881	0.275	0.314	1.447	2.412
2012-13	0.858	0.310	0.220	1.496	2.358
2013-14	0.835	0.347	0.121	1.549	2.305
2014-15	0.812	0.386	0.018	1.607	2.253
2015-16	0.609	0.456	-0.330	1.548	1.839
2016-17	0.583	0.501	-0.447	1.614	1.792
2017-18	0.558	0.546	-0.567	1.683	1.747
2018-19	0.532	0.593	-0.689	1.754	1.703

Table A-4: Prediction of productivity for bastar plateau under rapeseed and mustard for next 8 years

Year	Predicted log (Productivity) (kg/ha)	Log(S.E.) log(kg/ha)	Confidence Interval (95%) log(000'tonnes)		Predicted Productivity (kg/ha)
			Lower limit	Upper limit	
2011-12	5.703	0.141	5.412	5.994	299.772
2012-13	5.635	0.159	5.308	5.963	280.156
2013-14	5.568	0.178	5.201	5.935	261.823
2014-15	5.500	0.198	5.092	5.908	244.690

2015-16	5.369	0.234	4.887	5.851	214.688
2016-17	5.293	0.257	4.764	5.823	198.949
2017-18	5.217	0.281	4.639	5.795	184.364
2018-19	5.141	0.305	4.513	5.768	170.848

Table A-5: Production function as influenced by the area and productivity of rapeseed and mustard in amalgamated Bastar plateau district for Period 1, Period 2, Period 3, Period 4, and Period 5 (Bastar Plateau:1983-84 to 2010-11)

Crop	Model: $\ln P(A,Y) = c_0+c_1 \ln A+c_2 \ln Y$							
	Production Function				Area effect	Yield effect	Total	%Adj R^2
Rapeseed and Mustard		lnt	lnA	lnY				
	lnP(A,Y)=	-6.916***	+ 0.994***	+1.003***	78.68***	21.02***	99.71***	99.69
Note: Significance codes- 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '#								

Appendix-B (Figures)

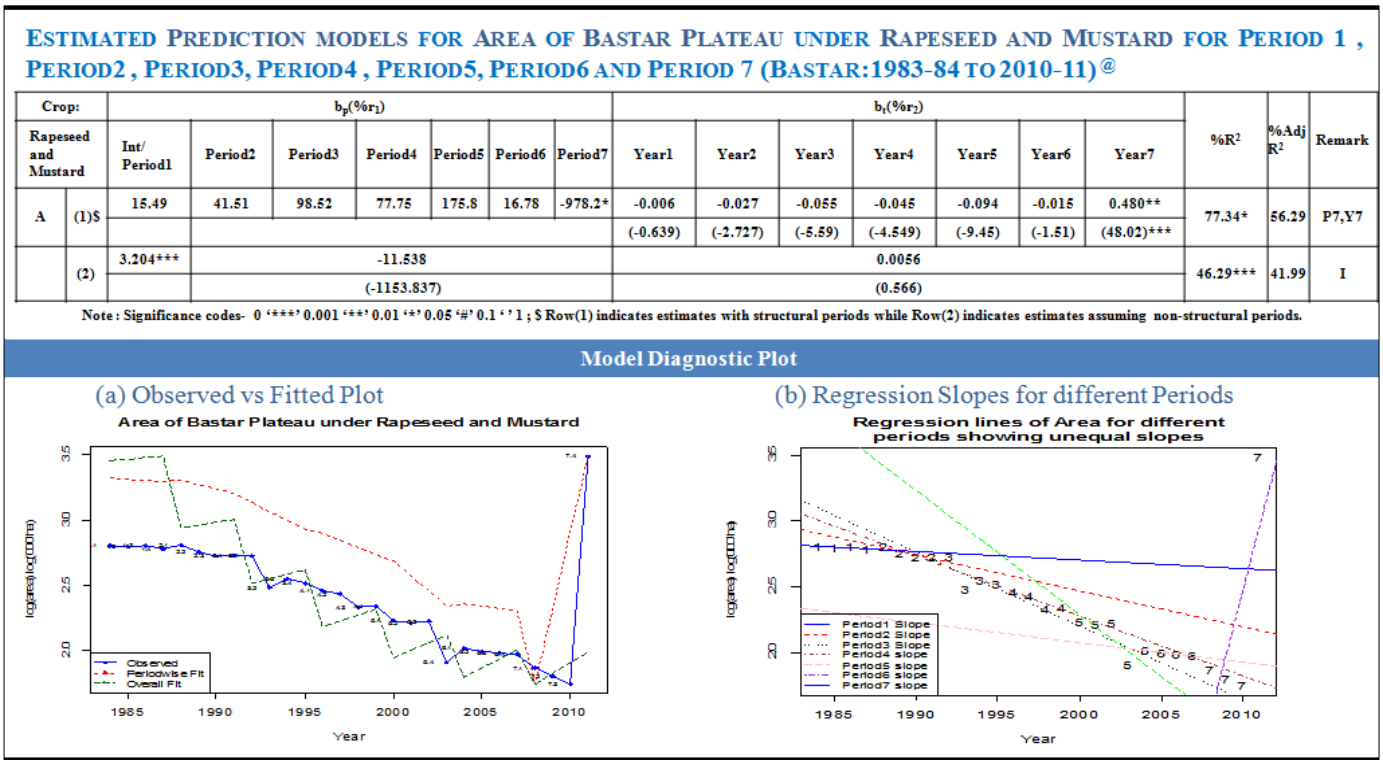

Fig B.1: Prediction models for Area of Bastar Plateau under Rapeseed and Mustard from 1983-84 to 2010-11 (a) Observed vs. Fitted Plot (b) Regression slopes for different periods.

ESTIMATED PREDICTION MODELS FOR AREA OF BASTAR PLATEAU UNDER RAPESEED AND MUSTARD FOR PERIOD 1 , PERIOD2 , PERIOD3, PERIOD4 , PERIOD5, PERIOD6 AND PERIOD 7 (BASTAR:1983-84 TO 2010-11)@

Crop:		$b_p(\%r_1)$							$b_t(\%r_2)$							$\%R^2$	$\%Adj\ R^2$	Remark
Rapeseed and Mustard		Int/ Period1	Period2	Period3	Period4	Period5	Period6	Period7	Year1	Year2	Year3	Year4	Year5	Year6	Year7			
A	(1)$	15.49	41.51	98.52	77.75	175.8	16.78	-978.2*	-0.006	-0.027	-0.055	-0.045	-0.094	-0.015	0.480**	77.34*	56.29	P7,Y7
									(-0.639)	(-2.727)	(-5.59)	(-4.549)	(-9.45)	(-1.51)	(48.02)***			
	(2)	3.204***	-11.538						0.0056							46.29***	41.99	I
			(-1153.837)						(0.566)									

Note : Significance codes- 0 '***' 0.001 '**' 0.01 '*' 0.05 '#' 0.1 ' ' 1 ; $ Row(1) indicates estimates with structural periods while Row(2) indicates estimates assuming non-structural periods.

Model Diagnostic Plot

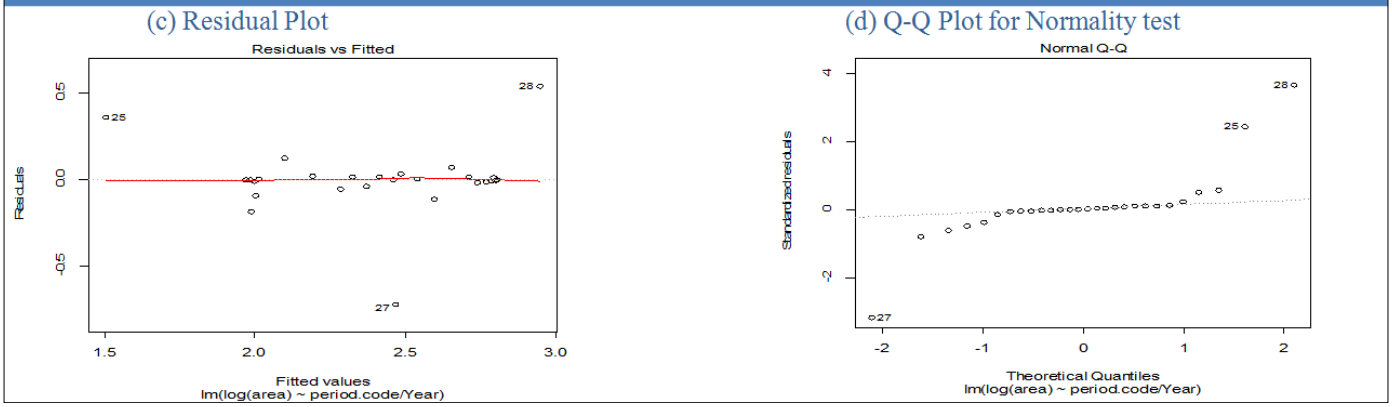

Fig B.2: Prediction models for Area of Bastar Plateau under Rapeseed and Mustard from 1983-84 to 2010-11 (c) Residual Plot (d) Q-Q Plot for Normality test.

ESTIMATED PREDICTION MODELS FOR PRODUCTION OF BASTAR PLATEAU UNDER RAPESEED AND MUSTARD FOR PERIOD 1 , PERIOD2 , PERIOD3, PERIOD4 , PERIOD5, PERIOD6 AND PERIOD 7 (BASTAR:1983-84 TO 2010-11)@

Crop:		$b_p(\%r_1)$							$b_t(\%r_2)$							$\%R^2$	$\%Adj\ R^2$	Remark
Rapeseed and Mustard		Int/ Period1	Period2	Period3	Period4	Period5	Period6	Period7	Year1	Year2	Year3	Year4	Year5	Year6	Year7			
P	(1)$	187.700	-203.300	45.760	-73.030	715.90#	-32.320	-1135*	-0.094	0.009	-0.116	-0.056	-0.451**	-0.077	0.472**	83.72**	68.6	P5,P7,Y5,Y7
									(-9.353)	(0.898)	(-11.61)	(-5.646)	(-45.08)**	(-7.694)	(47.21)**			
	(2)	2.235***	5.542						-0.0028							41.54**	36.86	I
			(554.207)						(-0.283)									

Note : Significance codes- 0 '***' 0.001 '**' 0.01 '*' 0.05 '#' 0.1 ' ' 1 ; $ Row(1) indicates estimates with structural periods while Row(2) indicates estimates assuming non-structural periods.

Model Diagnostic Plot

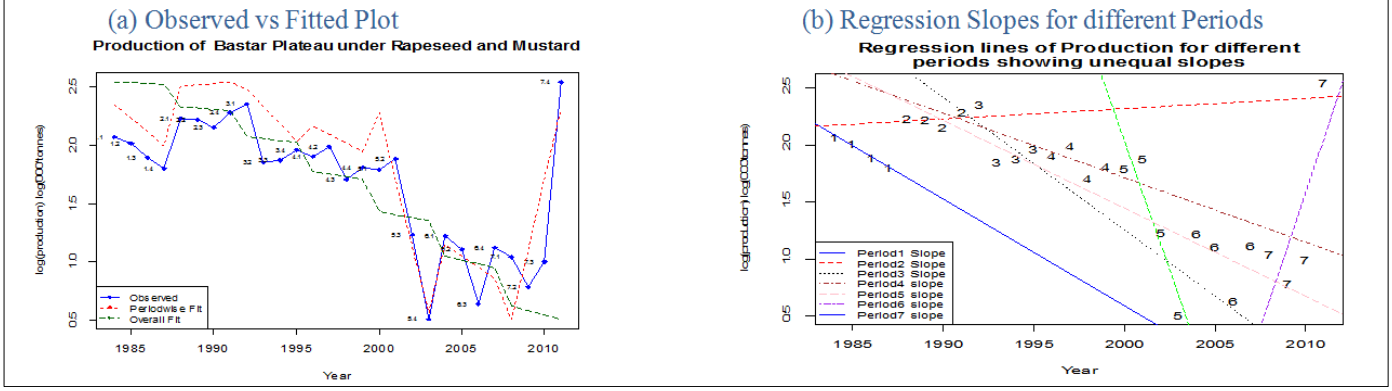

Fig B.3: Prediction models for Production of Bastar Plateau under Rapeseed and Mustard from 1983-84 to 2010-11 (a) Observed vs. Fitted Plot (b) Regression slopes for different periods.

ESTIMATED PREDICTION MODELS FOR PRODUCTION OF BASTAR PLATEAU UNDER RAPESEED AND MUSTARD FOR PERIOD 1, PERIOD2 , PERIOD3, PERIOD4 , PERIOD5, PERIOD6 AND PERIOD7 (BASTAR:1983-84 TO 2010-11)@

Crop:		$b_p(\%r_1)$							$b_t(\%r_2)$							%R²	%Adj R²	Remark
Rapeseed and Mustard		Int/ Period1	Period2	Period3	Period4	Period5	Period6	Period7	Year1	Year2	Year3	Year4	Year5	Year6	Year7			
P	(1)$	187.700	-203.300	45.760	-73.030	715.90#	-32.320	-1135*	-0.094	0.009	-0.116	-0.056	-0.451**	-0.077	0.472**	83.72**	68.6	P5,P7,Y5, Y7
									(-9.353)	(0.898)	(-11.61)	(-5.646)	(-45.08)**	(-7.694)	(47.21)**			
	(2)	2.235***	5.542						-0.0028							41.54**	36.86	I
			(554.207)						(-0.283)									

Note : Significance codes- 0 '***' 0.001 '**' 0.01 '*' 0.05 '#' 0.1 ' ' 1 ; $ Row(1) indicates estimates with structural periods while Row(2) indicates estimates assuming non-structural periods.

Model Diagnostic Plot

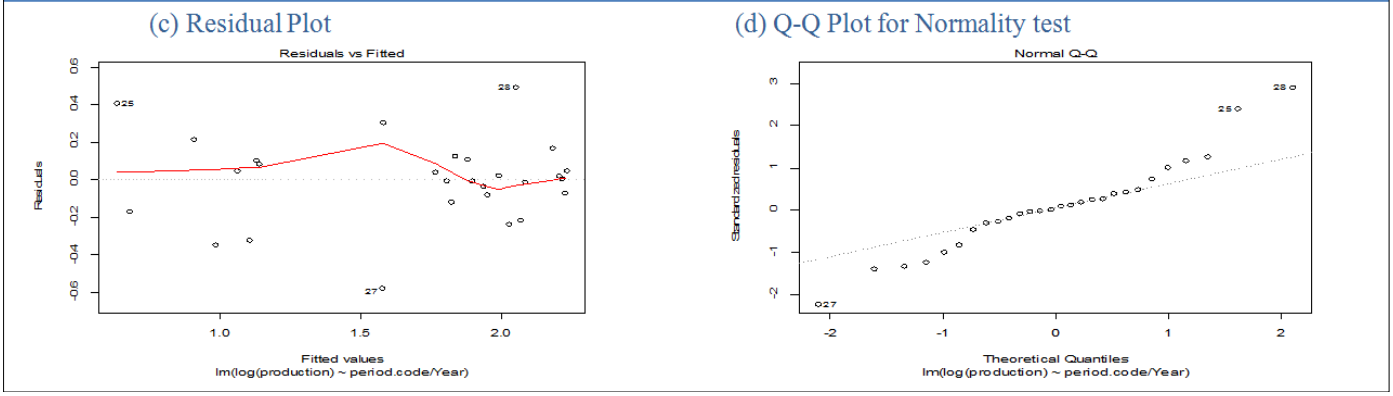

Fig B.4: Prediction models for Production of Bastar Plateau under Rapeseed and Mustard from 1983-84 to 2010-11 (c) Residual Plot (d) Q-Q Plot for Normality test.

ESTIMATED PREDICTION MODELS FOR PRODUCTIVITY OF BASTAR PLATEAU UNDER RAPESEED AND MUSTARD FOR PERIOD 1 , PERIOD2 , PERIOD3, PERIOD4 , PERIOD5, PERIOD6 AND PERIOD7 (BASTAR:1983-84 TO 2010-11)@

Crop:		$b_p(\%r_1)$							$b_t(\%r_2)$							%R²	%Adj R²	Remark
Rapeseed and Mustard		Int/ Period1	Period2	Period3	Period4	Period5	Period6	Period7	Year1	Year2	Year3	Year4	Year5	Year6	Year7			
Y	(1)$	179.000	-244.80	-51.00	-147.90	575.30*	-50.260	-164.30	-0.087	0.036	-0.061	-0.012	-0.374***	-0.061	-0.004	81.3**	63.94	P5,Y5
									(-8.71)	(3.629)	(-6.102)	(-1.24)	(-37.38)***	(-6.121)	(-0.4316)			
	(2)	5.937***	16.991**						-0.0084**							44.49***	40.05	I, P, Y
			(1699.147)**						(-0.846)***									

Note : Significance codes- 0 '***' 0.001 '**' 0.01 '*' 0.05 '#' 0.1 ' ' 1 ; $ Row(1) indicates estimates with structural periods while Row(2) indicates estimates assuming non-structural periods.

Model Diagnostic Plot

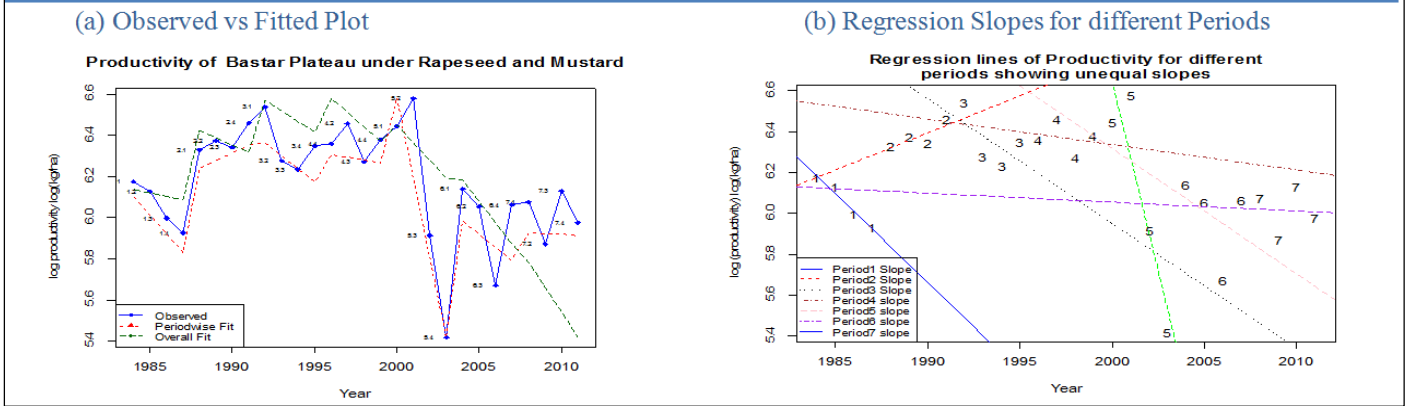

Fig B.5: Prediction models for Productivity of Bastar Plateau under Rapeseed and Mustard from 1983-84 to 2010-11 (a) Observed vs. Fitted Plot (b) Regression slopes for different periods.

ESTIMATED PREDICTION MODELS FOR PRODUCTIVITY OF BASTAR PLATEAU UNDER RAPESEED AND MUSTARD FOR PERIOD 1 , PERIOD2 , PERIOD3, PERIOD4 , PERIOD5, PERIOD6 AND PERIOD7 (BASTAR PLATEAU:1983-84 TO 2010-11)@

Crop:		$b_p(\%r_1)$							$b_t(\%r_2)$							$\%R^2$	$\%Adj\ R^2$	Remark
Rapeseed and Mustard		Int/ Period1	Period2	Period3	Period4	Period5	Period6	Period7	Year1	Year2	Year3	Year4	Year5	Year6	Year7			
Y	(1)$	179.000	-244.80	-51.00	-147.90	575.30*	-50.260	-164.30	-0.087	0.036	-0.061	-0.012	-0.374***	-0.061	-0.004	81.3**	63.94	P5,Y5
									(-8.71)	(3.629)	(-6.102)	(-1.24)	(-37.38)***	(-6.121)	(-0.4316)			
	(2)	5.937***	16.991**						-0.0084**							44.49***	40.05	I, P, Y
			(1699.147)**						(-0.846)***									

Note : Significance codes- 0 '***' 0.001 '**' 0.01 '*' 0.05 '#' 0.1 ' ' 1 ; $ Row(1) indicates estimates with structural periods while Row(2) indicates estimates assuming non-structural periods.

Model Diagnostic Plot

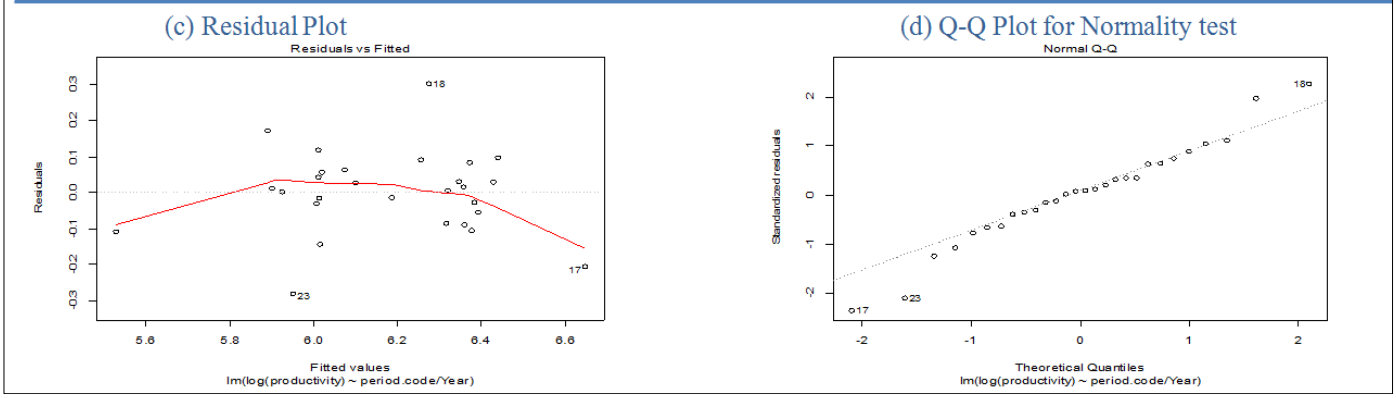

Fig B.6: Prediction models for Productivity of Bastar Plateau under Rapeseed and Mustard from 1983-84 to 2010-11 (c) Residual Plot (d) Q-Q Plot for Normality test.

PREDICTION OF AREA FOR BASTAR PLATEAU UNDER RAPESEED AND MUSTARD FOR NEXT 8 YEARS FROM 2011-12 TO 2018-19

Year	Predicted log(Area) log(000'ha)	Log(S.E.) log(000'ha)	Confidence Interval (95%) log(000'ha)		Predicted Area (000'ha)
			Lower limit	Upper limit	
2011-12	2.092	0.195	1.690	2.495	8.105
2012-13	2.138	0.220	1.684	2.591	8.481
2013-14	2.183	0.247	1.675	2.691	8.874
2014-15	2.228	0.274	1.664	2.793	9.285
2015-16	2.157	0.324	1.490	2.825	8.649
2016-17	2.208	0.356	1.475	2.942	9.102
2017-18	2.259	0.389	1.459	3.060	9.578
2018-19	2.310	0.422	1.442	3.179	10.079

PREDICTION PLOT OF AREA FOR BASTAR PLATEAU UNDER RAPESEED AND MUSTARD FOR 8 YEARS

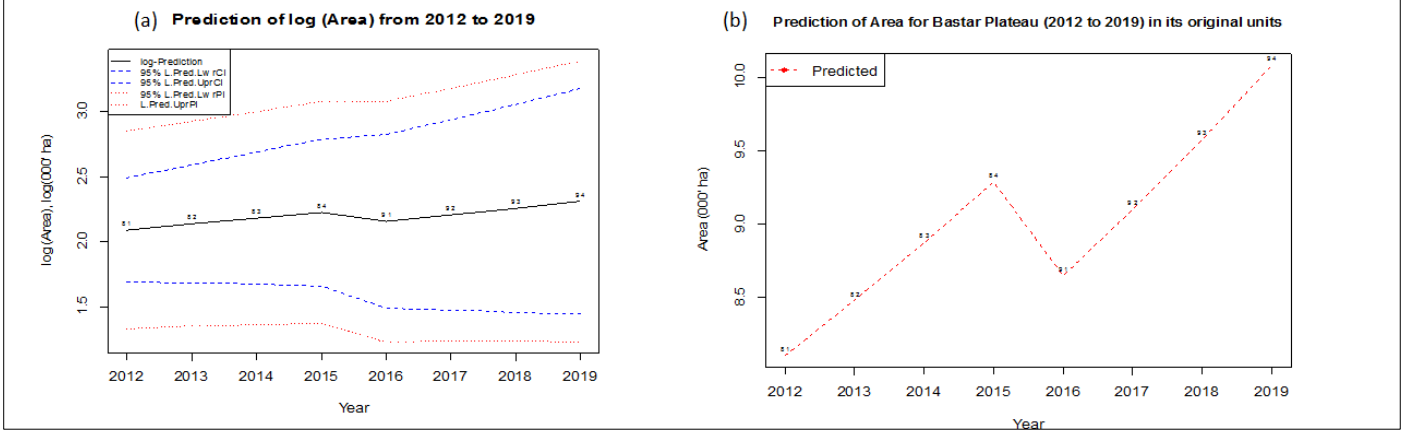

Fig B.7: Prediction of Area for Bastar Plateau under Rapeseed and Mustard for next 8 years from 2011-12 to 2018-19 (a) Predicted area (b) prediction compared with observed area.

PREDICTION OF PRODUCTION FOR BASTAR PLATEAU UNDER RAPESEED AND MUSTARD FOR NEXT 8 YEARS FROM 2011-12 TO 2018-19

Year	Predicted log(Production) (000'tonnes)	Log(S.E.) log(000'tonnes)	Confidence Interval (95%) log(000'tonnes)		Predicted Production (000'tonnes)
			Lower limit	Upper limit	
2011-12	0.881	0.275	0.314	1.447	2.412
2012-13	0.858	0.310	0.220	1.496	2.358
2013-14	0.835	0.347	0.121	1.549	2.305
2014-15	0.812	0.386	0.018	1.607	2.253
2015-16	0.609	0.456	-0.330	1.548	1.839
2016-17	0.583	0.501	-0.447	1.614	1.792
2017-18	0.558	0.546	-0.567	1.683	1.747
2018-19	0.532	0.593	-0.689	1.754	1.703

PREDICTION PLOT OF PRODUCTION FOR BASTAR PLATEAU UNDER RAPESEED AND MUSTARD FOR 8 YEARS

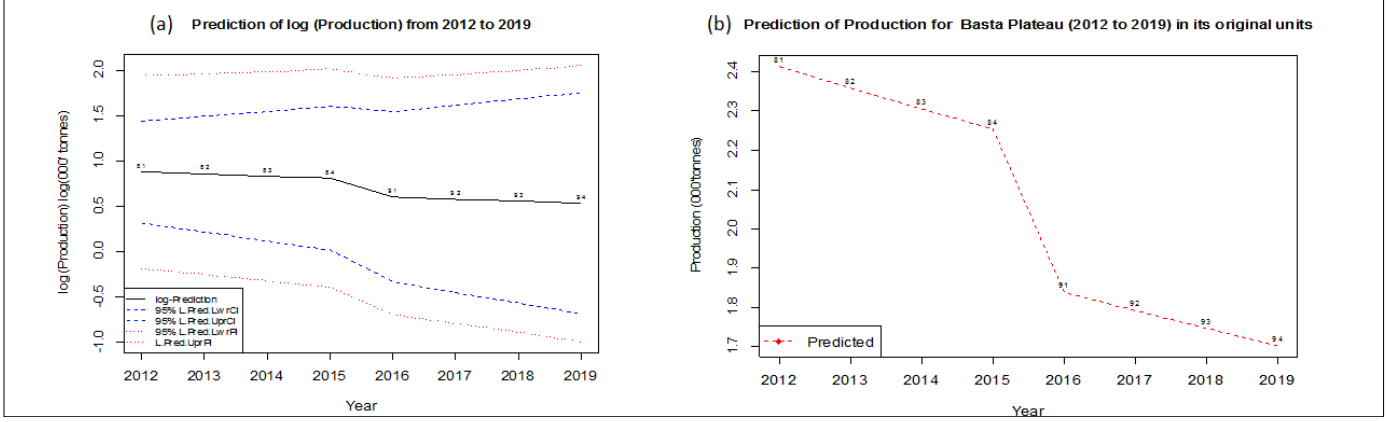

Fig B.8: Prediction of Production for Bastar Plateau under Rapeseed and Mustard for next 8 years from 2011-12 to 2018-19 (a) Predicted production (b) prediction compared with observed production.

PREDICTION OF PRODUCTIVITY FOR BASTAR PLATEAU UNDER RAPESEED AND MUSTARD FOR NEXT 8 YEARS FROM 2011-12 TO 2018-19

Year	Predicted log(Productivity) (kg/ha)	Log(S.E.) log(kg/ha)	Confidence Interval (95%) log(000'tonnes)		Predicted Productivity (kg/ha)
			Lower limit	Upper limit	
2011-12	5.703	0.141	5.412	5.994	299.772
2012-13	5.635	0.159	5.308	5.963	280.156
2013-14	5.568	0.178	5.201	5.935	261.823
2014-15	5.500	0.198	5.092	5.908	244.690
2015-16	5.369	0.234	4.887	5.851	214.688
2016-17	5.293	0.257	4.764	5.823	198.949
2017-18	5.217	0.281	4.639	5.795	184.364
2018-19	5.141	0.305	4.513	5.768	170.848

PREDICTION PLOT OF PRODUCTIVITY FOR BASTAR PLATEAU UNDER RAPESEED AND MUSTARD FOR 8 YEARS

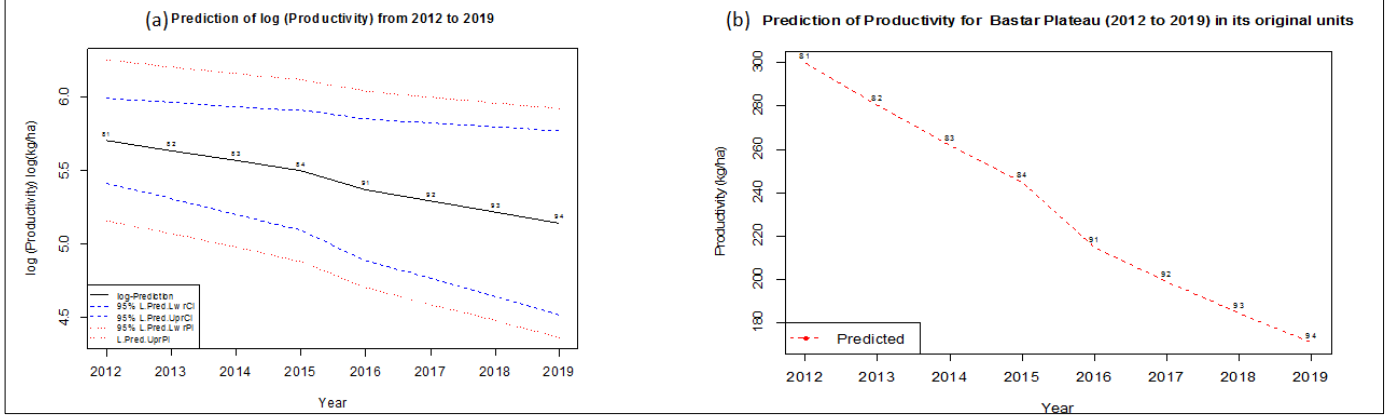

Fig B.9: Prediction of Productivity for Bastar Plateau under Rapeseed and Mustard for next 8 years from 2011-12 to 2018-19 (a) Predicted productivity (b) prediction compared with observed productivity.

PRODUCTION FUNCTION AS INFLUENCED BY THE AREA AND PRODUCTIVITY OF RAPESEED AND MUSTARD IN BASTAR PLATEAU FOR PERIOD1, PERIOD2, PERIOD3, PERIOD4, PERIOD5, PERIOD6 AND PERIOD7 (BASTER PLATEAU:1983-84 TO 2010-11)

Crop	Model: $\ln P(A,Y) = c_0+c_1 \ln A+c_2 \ln Y$							
	Production Function							
Rapeseed and Mustard		lnt	lnA	lnY	Area effect	Yield effect	Total	%Adj R^2
	lnP(A,Y)=	-6.916***	0.994***	1.003***	78.68***	21.02***	99.71***	99.69

Note:Significance codes- 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '#

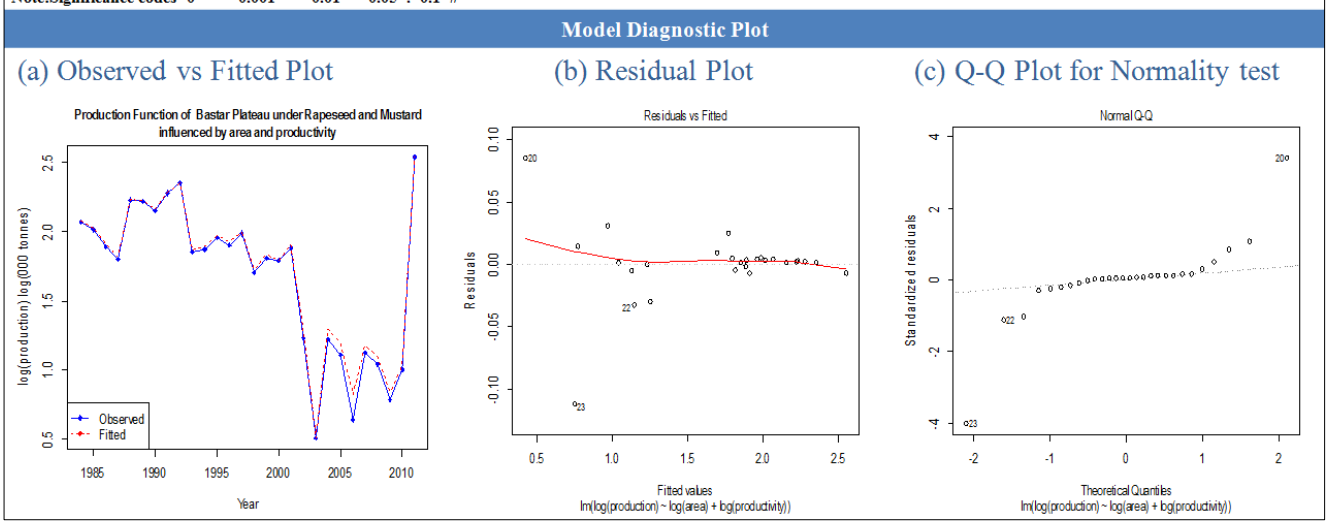

Fig B.10: Production function as influenced by Area and Productivity under Rapeseed and Mustard in Bastar Plateau from 1983-84 to 2010-11 (a) Observed vs. Fitted Plot (b) Residual Plot (c) Q-Q Plot for normality test.

Conclusion

It can be concluded from the present study that the estimated predictive models for area, production and productivity under Rapeseed and Mustard crop in Bastar plateau region were highly significant for both the model-1 and model-2. For area under Rapeseed and Mustard, model-1, predictive model was mainly dependent on the changes occurring in period-7and on annual growth rate for Year-7. Similarly for model-2 both the periodic effect and annual effect/growth rate were found to be non-significant. For production under Rapeseed and Mustard, model-1, the predictive model mainly depended on changes due to periodic effects period-5 and period-7 and annual effects/growth rates under Year-5 and Year-7 whereas for model-2 both the periodic effect and annual effect/growth rate were found to be non-significant. However, for productivity under Rapeseed and Mustard, model-1, the predictive model was mainly affected by changes in periodic effect period-5 and annual effects/growth rates for Year-5, while for model-2 both the periodic effect and annual effect were effective.

The predictions for area, production and productivity of Bastar plateau region are good enough from 2011-12 to 2014-15, beyond which the confidence interval widens. The influence of area and productivity on production gives a moderately good model fit (i.e. a robust fit), wherein it is concluded that the area alone has significantly contributed towards production of Rapeseed and Mustard in Bastar plateau to the extent of 78.68% in contrast to the influence of productivity (21.02%), which shows that there is lack of awareness among farmers of Rapeseed and Mustard with respect to use of technology in Rapeseed and Mustard production in Bastar plateau.

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