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Analytical study of growth and instability of rabi oilseed production in Odisha

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Abstract
Agriculture is the chief occupation in Odisha. The most commonly grown oilseeds in Odisha are groundnut, mustard, sesame, sunflower etc. The study of growth and variability in area, yield and production of oilseeds is very important for effective planning and strategy formulation. The study is based on secondary source of data on area, production and yield of oilseed crops for rabi season in the districts of Odisha from the period 1993-94 to 2016-17. The compound growth rate and Coppock's instability index are used as a measure of growth and instability of area, yield and production of rabi oilseeds. Also the districts of Odisha are ranked on basis of compound growth rate and Coppock's instability index of area, yield and production of rabi oilseeds. The compound growth rate of yield of rabi oilseeds in Odisha is positive and significant due to which the compound growth rate of production of rabi oilseeds is significantly positive despite of significantly negative compound growth rate in area under of rabi oilseeds. Growth rate of area and yield of rabi oilseeds should be enhanced by increasing the chances of assured irrigation and by adopting improved cultivation practices.

Keywords: Compound growth rate, coppock's instability index, production, significant

Introduction

Oilseeds constitute a very important group of commercial crops in India and also in Odisha. Odisha Agriculture is the major contributor to the state's economy. Agriculture is the chief occupation in Odisha. The oil extracted from oilseeds form an important item of our diet and are used as raw materials for manufacturing large number of items like paints, varnishes, hydrogenated oil, soaps, perfumery, lubricants, etc. The most commonly grown oilseeds in Odisha are groundnut, mustard, sesame, sunflower etc. Due to the economical values of these crops, these are considered as the most important crops all over the country as well as for the state of odisha. Primarily the oilseeds are grown for edible oil. Odisha has the total oilseed yield rate of 928 kg/ha (Odisha Agricultural Statistics, Govt. of Odisha, 2015-16) which is less than the total oilseed yield of India i.e. 1153 kg/ha according to the records of 2015-16 The study of growth and variability in area, yield and production of oilseeds is very important for effective planning and strategy formulation. The present study aims at analyzing the district level growth and instability of oilseeds during rabi season in the state of Odisha from 1993-94 to 2016-17. Keeping in view the above perspectives the study has been made regarding area, yield and production of rabi oilseeds in all the 30 districts of Odisha for kharif seasons is done for the period 1993-94 to 2016-17. Dash, *et al*. (2017) [2] studied the growth rate and instability of area, yield and production of food grain in Odisha using the best fit model and the model selected on the basis of scatter plot of the data.

Material and Methods

The study is based on secondary source of data on area, production and yield of oilseed crops for rabi season in the districts of Odisha from the period 1993-94 to 2016-17. The data are obtained from various volumes of Odisha Agriculture Statistic published by Directorate of Agriculture and Food Production, Government of Odisha.

Compound growth rate (CGR)

The data on area, production and yield of oilseed crops for rabi season in Odisha were worked out for entire period of analysis by fitting to exponential functions as follows.

$$Y_t = ab^t$$

Where, Y_t = Area / Production / Yield of oilseed crops in years.

t = time element which takes the value 1,2,3,…..,n
a = intercept; b = regression coefficient

The compound growth model is established in the following manner,

ln Y $_t$ = ln a + t ln b
Y $_t'$= A′+B′t
Let ln Y $_t$ = Y $_t'$
ln a = A′
ln b = B′

The two generalised equations are

$$\sum_{t=1}^{n} Y_t' = \sum_{t=1}^{n}\left(A' + B't\right)$$

$$\sum_{t=1}^{n} Y_t' = nA' + B'\sum_{t=1}^{n} t \qquad \text{…equation 1}$$

$$\sum_{t=1}^{n} tY_t' = A'\sum_{t=1}^{n} t + B'\sum_{t=1}^{n} t^2 \qquad \text{… equation 2}$$

Solving the two equations and multiplying equation 1 by $\sum_{t=1}^{n} t$ on both sides we get

$$\sum_{t=1}^{n} Y_t'.\sum_{t=1}^{n} t = nA'\sum_{t=1}^{n} t + B'(\sum_{t=}^{n} t)^2 \qquad \text{…equation 3}$$

Multiplying equation 2 by n on both sides we get

$$n\sum_{t=1}^{n} tY_t' = nA'\sum_{t=1}^{n} t + nB'\sum_{t=1}^{n} t^2 \qquad \text{...equation 4}$$

By Equation 3 – Equation 4 we get

$$n\sum_{t=1}^{n} tY_t' - \sum_{t=1}^{n} Y_t'.\sum_{t=1}^{n} t = nB^1\sum_{t=1}^{n} t^2 - B'\left(\sum_{t=1}^{n} t\right)^2$$

$$=> B' = \frac{n\sum_{t=1}^{n} tY_t' - \sum_{t=1}^{n} t.\sum_{t=1}^{n} Y_t'}{n\sum_{t=1}^{n} t^2 - \left(\sum_{t=1}^{n} t\right)^2}$$

Putting the value of B′ in equation 1 we get

$$A= (\sum_{t=}^{n} Y_t' - B\sum_{t=1}^{n} t)/n$$

Given,
ln a = A′ ; a= e $^{A'}$; log b= B′; b= e $^{B'}$

Compound growth rate (C.G.R.) = (b - 1)× 100 (Dhakre and Sharma, 2010) [3]

Coppock's instability index is a close approximation of the average year to year percentage variation adjusted for trend and the advantage is that it measures the instability in relation to the trend in prices. A higher numerical value for the index represents greater instability. It is represented by the following formula,

$$\text{Coppock's instability index} = \text{Antilog}\left(\sqrt{\log V} - 1\right)\times 100$$

$$\Rightarrow \log V = \left(\sum_{t=1}^{n} \log\frac{X_{t+1}}{X_t} - m\right)^2$$

Where, log V is the log variance; m = $\sum_{t=1}^{n} \log\frac{X_{t+1}}{X_t}$

(Anjum and Madhulika, 2018)

Here X represents production / area / yield
m= mean value of successive differences of log values

Spearman's rank correlation coefficient
Spearman's rank correlation coefficient denoted by ρ is a non-parametric measure of rank correlation. It assesses how well the relationship between two variables can be described using monotonic function.
The Spearman's correlation between two variables is equal to the Karl Pearson's correlation coefficient between rank values of those two variables and Pearson's correlation assesses linear relationships.
Spearman's formula for rank correlation coefficient,

$$\rho = \frac{1 - 6\sum_{i=1}^{n} d_i^2}{n(n^2 - 1)}$$

Where,
d_i = difference between two ranks of each observations
n= number of observations

Test of significance of correlation coefficient:
The significance of the correlation is tested using t- test.
Let us assume the population correlation coefficient between Area & Production and Yield & Production be zero.
So,

H_0: ρ = 0
H_1: ρ ≠ 0

Level of significance (α) = 0.05 (5%) or 0.01(1%)
Test statistic is given by

$$t_{Cal} = \frac{r}{SE(r)}$$

$$SE(r) = \frac{1 - r^2}{n - 2}$$

Tabulated t values are obtained from t-table. Tab t values are found for 0.05 and 0.01 level of significance at (n-2) d.f as the case may be.

Let the Tabulated t value for 0.05 and 0.01 level of significance be represented by t_1 and t_2 respectively.

If $|t_{cal}| > t_2$ then we reject the null hypothesis at 1% level of significance. Here t is considered to be highly significant and correlation between Area- Production and Yield –Production of two periods differ significantly at 1% level of significance.

If $|t_{cal}| < t_1$ we accept null hypothesis. Here t is considered to be insignificant and we conclude that correlation don't differ significantly.

If $t_1 < |t_{cal}| < t_2$, then we reject null hypothesis only at 5% level of significance. Here t is considered to be significant and we conclude that correlation differs significantly at 5% level of significance.

Results and Discussion

Table 1 shows that though the compound growth rate of area under rabi oilseeds in Odisha is negative and significant the significantly positive compound growth rate of yield of rabi oilseeds is responsible for the significantly positive compound growth rate of production of oilseeds. Among the districts most of them show negative compound growth rate of area under rabi oilseeds. Most of the districts show positive compound growth rate in yield which is also significant. Only a few districts like Bargarh, Deogarh, Jharsuguda, Keonjhar and Nayagarh show negative and significant compound growth rate in yield of rabi food grains. The compound growth rate of production is also positive and significant in many districts except a few like Gajapati, Jagatsinghpur, Koraput and Nayagarh which show significantly negative compound growth rate in production of rabi oilseeds.

Table 2 shows that the in Odisha Instability is highest in case of production of rabi oilseeds than that in area and yield. Thus the high instability in production is due to interaction effect of area and yield. The districts like Anugul, Nuapada, Ganjam and Jajpur have very high rate of instability in production of rabi oilseeds which goes above 60%. The instability in area is below 50% for most of the districts except Ganjam, Nuapada, Malkangiri and Sambalpur s above 50%. Yield of rabi oilseeds is below 50% for many districts of Odisha though few districts like Anugul, Dhenkanal, Jajpur, Malkangiri have quite high rate of instability.

Table 3 shows that Deogarh district secured the first rank with respect to compound growth rate of area under rabi oilseeds followed by Bhadrak. Koraput district has the last rank among the districts of Odisha on compound growth rate of area under rabi oilseeds. In case of instability of area under rabi oilseeds, Jajpur occupied the first position followed by Puri and the last position is occupied by Malkangiri.

In case of compound growth rate of yield of rabi oilseeds as evident from table 4, Malkangiri also secured first position followed by Bolangir and last rank is occupied by Jharsuguda. Deogarh secured first position followed by Balasore district and last rank is occupied by Anugul with respect to instability in yield of rabi oilseeds.

Table 5 shows that in case of compound growth rate of production of rabi oilseeds, Bhadrak district occupied the first position followed by Nuapada and Jajpur districts and the last position is occupied by Nayagarh district. Puri secured first position followed by Bhadrak district and last rank is occupied by Nuapada with respect to instability in production of rabi oilseeds.

Table 6 which shows the rank correlation coefficient between the compound growth rate and instability of area, yield and production of rabi oilseeds in Odisha, reveals that the rank correlation is significantly negative in case of yield, whereas, in case of area it is negative but non-significant and in case of production it is positive but non-significant.

Table 1: Compound growth rate (in %) of rabi oilseeds of different districts of Odisha

Sl. No.	Districts	Area	Yield	Production	Sl No	Districts	Area	Yield	Production
1	Angul	0.13**	1.09	1.24	16	Kandhamal	-1.45	0.15	-1.29
2	Balasore	2.07**	2.72**	4.85**	17	Kendrapada	-2.57**	1.62**	-0.99**
3	Bargarh	0.36	-0.83**	-0.47	18	Keonjhar	-1.64**	-0.69**	-2.33**
4	Bhadrak	2.89**	2.72**	5.69**	19	Khurda	0.43	2.84**	3.24
5	Bolangir	0.88	3.77**	4.70**	20	Koraput	-4.93**	2.56**	-2.49**
6	Boudh	1.31**	3.11**	4.46**	21	Malkangiri	0.10	5.23**	5.34
7	Cuttack	-1.09**	1.78**	0.67	22	Mayurbhanj	-0.63**	1.47**	0.82
8	Deogarh	3.52**	-1.12**	2.36**	23	Nabarangpur	-2.49**	3.05**	0.48
9	Dhenkanal	-1.75**	1.64**	0.63	24	Nayagarh	-2.44**	-0.96**	-3.37**
10	Gajapati	-0.97**	0.44	-0.53**	25	Nuapada	1.91**	3.44**	5.42**
11	Ganjam	0.001	1.38**	1.63**	26	Puri	0.70**	1.91**	2.63**
12	Jagatsinghpur	-2.32**	1.09**	-1.25**	27	Rayagada	-3.04**	2.13**	-0.97
13	Jajpur	0.11**	0.72	0.83	28	Sambalpur	1.01	-0.08	0.93
14	Jharsuguda	2.73**	-1.12**	1.57**	29	Subarnapur	0.51	2.28**	2.80**
15	Kalahandi	0.58**	2.34**	2.96**	30	Sundargarh	-0.71**	0.26	-0.45
	Odisha	-0.49**	1.59**	1.09**					

*signifies significant at 5% and **signifies significant at 1%

Table 2: Coppock's Instability Index (in %) of rabi oilseeds of different districts of Odisha

Sl No.	Districts	Area	Yield	Production	Sl No.	Districts	Area	Yield	Production
1	Angul	19.33	61.45	76.26	16	Kandhamal	34.53	31.57	56.36
2	Balasore	19.28	17.52	49.29	17	Kendrapada	12.76	22.48	29.10
3	Bargarh	29.24	22.16	43.77	18	Keonjhar	17.42	22.93	32.29
4	Bhadrak	18.11	19.15	24.02	19	Khurda	49.75	47.37	58.28
5	Bolangir	37.12	25.06	47.81	20	Koraput	38.58	26.58	40.19
6	Boudh	24.37	31.21	49.46	21	Malkangiri	62.59	55.13	44.65
7	Cuttack	17.72	29.43	34.68	22	Mayurbhanj	32.78	23.12	43.84
8	Deogarh	30.72	14.22	38.75	23	Nabarangpur	22.16	31.78	41.19
9	Dhenkanal	23.16	51.73	61.68	24	Nayagarh	41.01	29.36	50.66
10	Gajapati	25.68	18.39	24.91	25	Nuapada	53.98	55.83	79.41
11	Ganjam	52.24	28.19	68.81	26	Puri	9.18	32.29	14.02
12	Jagatsinghpur	18.27	34.73	36.93	27	Rayagada	16.85	41.23	52.58
13	Jajpur	7.37	59.56	60.43	28	Sambalpur	57.57	23.91	53.25
14	Jharsuguda	46.96	18.10	49.73	29	Subarnapur	22.81	19.73	38.69
15	Kalahandi	30.80	19.26	36.28	30	Sundargarh	27.27	19.30	42.88
	Odisha	15.97	20.89	32.39					

Table 3: Rank of the districts on basis of Compound growth rate (C.G.R) and Coppock's Instability Index (CII) of area under oilseeds for rabi season

Sl No.	Districts	Rabi		Sl No.	Districts	Rabi	
		CGR	CII			CGR	CII
1	Angul	14	10	16	Kandhamal	22	21
2	Balasore	4	9	17	Kendrapada	28	3
3	Bargarh	13	17	18	Keonjhar	23	5
4	Bhadrak	2	7	19	Khurda	12	26
5	Bolangir	8	22	20	Koraput	30	23
6	Boudh	6	14	21	Malkangir	16	30
7	Cuttack	21	6	22	Mayurbhanj	18	20
8	Deogarh	1	18	23	Nabarangpur	27	11
9	Dhenkanal	24	13	24	Nayagarh	26	24
10	Gajapati	20	15	25	Nuapada	5	28
11	Ganjam	17	27	26	Puri	9	2
12	Jagatsinghpur	25	8	27	Rayagada	29	4
13	Jajpur	15	1	28	Sambalpur	7	29
14	Jharsuguda	3	25	29	Subarnapur	11	12
15	Kalahandi	10	19	30	Sundargarh	19	16

Table 4: Rank of the districts on basis of Compound growth rate (C.G.R) and Coppock's Instability Index (CII) of yield of oilseeds for rabi season

Sl No.	Districts	Rabi		Sl No.	Districts	Rabi	
		CGR	CII			CGR	CII
1	Angul	19	30	16	Kandhamal	24	20
2	Balasore	7	2	17	Kendrapada	16	10
3	Bargarh	27	9	18	Keonjhar	26	11
4	Bhadrak	8	5	19	Khurda	6	25
5	Bolangir	2	14	20	Koraput	9	15
6	Boudh	4	19	21	Malkangiri	1	27
7	Cuttack	14	18	22	Mayurbhanj	17	12
8	Deogarh	29	1	23	Nabarangpur	5	21
9	Dhenkanal	15	26	24	Nayagarh	28	17
10	Gajapati	22	4	25	Nuapada	3	28
11	Ganjam	18	16	26	Puri	13	22
12	Jagatsinghpur	20	23	27	Rayagada	12	24
13	Jajpur	21	29	28	Sambalpur	25	13
14	Jharsuguda	30	3	29	Subarnapur	11	8
15	Kalahandi	10	6	30	Sundargarh	23	7

Table 5: Rank of the districts on basis of Compound growth rate (C.G.R) and Coppock's Instability Index (CII) of production of oilseeds for rabi seasons

Sl No.	Districts	Rabi		Sl No.	Districts	Rabi	
		CGR	CII			CGR	CII
1	Angul	14	29	16	Kandhamal	27	24
2	Balasore	4	18	17	Kendrapada	25	4
3	Bargarh	22	14	18	Keonjhar	28	5
4	Bhadrak	1	2	19	Khurda	7	25
5	Bolangir	5	17	20	Koraput	29	11
6	Boudh	6	19	21	Malkangir	3	16
7	Cuttack	18	6	22	Mayurbhanj	17	15
8	Deogarh	11	10	23	Nabarangpur	20	12
9	Dhenkanal	19	27	24	Nayagarh	30	21
10	Gajapati	23	3	25	Nuapada	2	30
11	Ganjam	12	28	26	Puri	10	1
12	Jagatsinghpur	26	8	27	Rayagada	24	22
13	Jajpur	16	26	28	Sambalpur	15	23
14	Jharsuguda	13	20	29	Subarnapur	9	9
15	Kalahandi	8	7	30	Sundargarh	21	13

Table 6: Rank correlation coefficient (RCC) between compound growth rate (CGR) and Coppock's Instability Index (CII) for area, yield and production of rabi oilseeds of Odisha

	Area	Yield	Production
RCC	0.227	-0.318	-0.13
SE(standard erreor)	0.184	0.1792	0.187
t	1.233	-1.775	-0.694
Highly significant/Significant/Non significant	Non significant	Significant	Non significant

Conclusions

The performance of rabi oilseeds as revealed from the analytical study is found to be poor with respect to area of rabi oilseeds. Though the yield performance is better than that of area, the performance should be enhanced to get a good increment in growth rate of yield of rabi oilseeds along with low degree of instability. This could probably be achieved by putting some more area under oilseeds during rabi season which could be made possible by increasing the chances of assured irrigation and by adopting improved cultivation practices for increasing the growth rate of yield. To enhance the growth rate of rabi oilseed production with decreased instability these steps are very much necessary.

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