Statistical analysis of growth and instability of rabi food grain production in coastal districts of Odisha, India

ABSTRACT

Agriculture is the backbone of the economy of Odisha, India. Food grain production in the state is mainly confined in the coastal areas. Coastal land, one of the important production systems occupying an area of about 10.78 million ha, has a significant contribution to the food grain production of the state. Food grains include both cereals and pulses. To study the variation in production of rabi food grains, a study is made about the area and yield of rabi food grains in these coastal districts from the year 1993-94 to 2014-15. For this purpose, the whole period of study (1993-94 to 2014-15) is divided into two sub-periods i.e. Period-I (1993-94 to 2002-03) and Period-II (2003-04 to 2014-15) on the basis of scatter plot of area, yield and production of rabi food grains of Odisha. This study includes test of significance of change in mean and variance of area, yield and production of rabi food grains from Period-I to Period-II. To test the significance of change in mean and variance of area, yield and production of rabi food grains from Period-I to Period-II, Fisher's t-test and Snedecor's F-test have been used, respectively. No significant change in mean area from Period-I to Period-II ~~is~~ was found but there is high variation in mean yield and mean production of rabi food grains. High variation in mean yield and mean production of rabi food grains is marked which may be due to uneven spread of technologies. The results of the study revealed that the variability (variance) in production of rabi food grains of Odisha increased from Period-I to Period-II. Change in coefficient of variation of area, yield and production of rabi food grains show significant decrease from Period-I to Period-II.

Keywords: food grains, production, scatter plot, mean, variance and coefficient of variation

INTRODUCTION

Agriculture is the chief occupation in Odisha. About 76% of the total working population is engaged with agriculture and agriculture related industries. The total cropped area in Odisha is 87~~,~~.46~~,~~.000 ha and out of that 18~~,~~.79~~,~~.000 ha are under irrigation. The principal problem that Odisha agriculture faces is the shortage of water in many areas. Lack of irrigation facilities in these droughts prone areas create great obstacles to the agriculture.

The entire rabi area is irrigated and covered by HY paddy where~~-~~as 36% of kharif area paddy area is covered under irrigation. The percentage of area under kharif and rabi food grains in coastal Odisha are 24.65% and 39.57% of the total area of the state, respectively.

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Likewise, in case of production, coastal Odisha contributes 24.41% and 31.77% in kharif and rabi seasons, respectively. In case of kharif and rabi cereals, coastal Odisha contributes 27.72% and 25.89% in area and 25.14% and 24.80% in production respectively as compared to the whole state. The percentage of area and production in kharif and rabi seasons of coastal Odisha are 6.09 %, 42.91 % and 6.72 %, 43.21 % as compared to the area and production of whole state.

Variability in production of food grains arises due to the deceleration in the trend growth rate of food grains production over time after the initial phase of green revolution and due to regional disparities in agricultural development which is primarily due to uneven spread of new agricultural technologies. The food grain production variance in coastal districts of Odisha is expected to change after a decade. So to study any possible change in production, the entire period of study would be divided into at least two periods on some statistical basis. The changes in the cropping pattern are generally viewed as a shift from traditionally- grown less-remunerative crops to more-remunerative crops (Mohanty et al., 2013).

During Green Revolution period, there was a continuous surge for diversifying agriculture in terms of crops, primarily on economic considerations (Joshi et al., 2006; Paltasingh and Goyari, 2013). Krishnaji (1979) observed the inequalities in inter-state and inter-districts per capita food grains production and productivity in India during 1950--53, 1960-63 and 1970-73. Mishra et al. (2014) considered ARIMA model on fertilizer statistics for India. Mishra et al. (2015) & Sahu and Mishra (2014) studied the instability of food grain and maize in India respectively. Tripathy *et al.* (2011) studied the inter-district disparities in agriculture of ~~odisha~~Odisha covering the period 1980-81 to 1992-93. Reddy (2013) studied regional disparities in agricultural growth in coastal plains and central Table Zones of Odisha from pre-liberalization (1971-90) to post-liberalization (19991-2008) periods. Kumar *et al.* (2012) studied the inter-district disparities in agricultural performance in Haryana over three periods i.e. 1990, during 1990-2002 and 2002-09.

Keeping in view of the above perspectives, the study has become made with the following objectives:

1. To find out a break point in the whole period of study with respect to area, yield and production of food grains in Odisha for rabi seasons on basis of scatter plot of the data and then accordingly divide the entire period of study into two periods i.e. Period-I and Period-II.

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2. To test the significance of change in mean and variance of area, yield and production of food grains from Period-I to Period-II for rabi seasons in coastal districts of Odisha and the state ~~as a whole~~.

The study regarding area, yield and production of food grains in the coastal districts of Odisha for rabi seasons is done for the period 1993-94 to 2014-15.

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MATERIALS AND METHODS

The study is based on the secondary source of data on area, production and yield of food grains in the coastal districts of Odisha for rabi seasons for the period 1993-94 to 2014-15. The data are obtained from various volumes of Odisha Agriculture Statistics published by the Directorate of Agriculture and Food Production, Government of Odisha.

To find the mean area/production/yield of both the periods of study the following formula ~~is~~ was used. For a sample $x_1, x_2,....,x_n$ of n observations Mean, $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$

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Fisher's t-test is used to test whether two independent sample means are significantly different or not. ~~So in this study, Fisher's t test is used~~. It is used for testing the significance of difference between the mean area/yield/production of two periods.

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To test this we take random samples of sizes n_1 and n_2 from the two populations.

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Null hypothesis, H_0: $\mu_1 = \mu_2$ i.e. the two--population means are identical.

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a) Alternative hypothesis, H_1:$\mu_1 \neq \mu_2$ (two tailed test)

We find the two sample means $\bar{x}_1$ and $\bar{x}_2$ to draw conclusions about μ_1 and μ_2.

b) Level of significance (α) is generally fixed at 5% or 1%.

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c) Test statistic, $$t = \frac{\left(\bar{x}_1 - \bar{x}_2\right)}{\left[S^2\left\{\left(\frac{1}{n_1}\right)+\left(\frac{1}{n_2}\right)\right\}\right]^{\frac{1}{2}}}$$

Here, S^2 is pooled variance and is given by: $$S^2 = \frac{\left[\sum_{i=1}^{n_1}\left(x_{1i} - \bar{x}_1\right)^2 + \sum_{i=1}^{n_2}\left(x_{2i} - \bar{x}_2\right)^2\right]}{\left(n_1 + n_2 - 2\right)}$$

$$\bar{x}_1 = \frac{\sum_{i=1}^{n_1} x_{1i}}{n_1}, \quad \bar{x}_2 = \frac{\sum_{i=1}^{n_2} x_{2i}}{n_2}$$

a) From the t-table, the critical value of t is obtained for $(n_1 + n_2 - 2)$ degrees of freedom at 0.05% and 0.01% level of significance.

b) Tabulated t values are found for 0.05% and 0.01% level of significance at $(n_1 + n_2 - 2)$ degrees of ~~freedom as the case may be~~freedom.

c) Let the t_{tab} for 0.05% and 0.01% level of significance be represented by t_1 and t_2 respectively.

d) 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 mean of two periods differ significantly at 1% level of significance.

e) If $t_{cal} < t_1$, we accept null hypothesis. Here t is considered to be in-significant and we conclude that mean of two period don't differ significantly.

d) If $t_1 < t_{cal} < t_2$, then we reject the null hypothesis only at 5% level of significance. Here t is considered to be significant and we conclude that mean of two periods differ significantly at 5% level of significance.

To find the variance (σ^2) of area/production/yield of both the periods of study the following formula is used: Variance, $\sigma^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}$

Test of significance of difference in the sample variances of area/yield/production for two different periods is done by Snedecor's F-test. It is a statistical test used to compare two variances.

The test procedure is as follows:

Null hypothesis~~:~~: H_0: $\sigma_1^2 = \sigma_2^2$ (where σ_1^2 and σ_2^2 are the two population variances)

Alternative hypothesis~~:~~: H_1: $\sigma_1^2 \neq \sigma_2^2$ (two-tailed test)

Level of significance: α, ~~$\propto$~~ = 0.05 (5%) or 0.01(1%)

Test statistic F is given by

$F = \frac{s_1^2}{s_2^2}$ (if $s_1^2 > s_2^2$) ~~Or~~ or $F = \frac{s_2^2}{s_1^2}$ (if $s_2^2 > s_1^2$)

s_1^2 = sample variance of period-I (1993-94 to 2002-03)

s_2^2 = sample variance of period-II (2003-04 to 2014-15)

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$$s_1^2 = \frac{1}{n_1 - 1}\left\{\sum_{i=1}^{n} x_i^2 - \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n_1}\right\} \qquad s_2^2 = \frac{1}{n_2 - 1}\left\{\sum_{i=1}^{n} x_i^2 - \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n_2}\right\}$$

e) Tab F values are obtained from F-table. Tab F values are found for 0.05% and 0.01% level of significance at (n_1-1, n_2-1) degrees of freedom as the case may be.

f) Let the tabulated F for 0.05% and 0.01% level of significance be represented by F_1 and F_2 respectively.

g) If Calculated F> F_2, then we reject the null hypothesis at 1% level of significance. Here F is considered to be highly significant and variance of two periods differ significantly at 1% level of significance.

h) If Calculated F_1< F_1, we accept null hypothesis. Here F is considered to be insignificant and we conclude that variances of two periods don't differ significantly.

i) If F_1< Calculated F <F_2, then we reject the null hypothesis only at 5% level of significance. Here F is considered to be significant and we conclude that variances of two periods differ significantly at 5% level of significance.

To find the coefficient of variation of area, yield and production for Period-I and Period-II, the following formula is used: $C.V. = \frac{S.D.}{Mean} \times 100$ Where, SD is the standard deviation.

The significance of the difference in coefficient of variation between first and second period in the population is tested using student's t-statistic.

Null hypothesis: H_0: $\Delta CV = 0$; Alternative hypothesis: H_1: $\Delta CV \neq 0$

Here the test statistic is given by $t = \frac{\Delta CV}{SE(\Delta CV)}$

The test statistic follows t-distribution with (2n-2) degrees of freedom, where 'n' is the number of observations in each period and SE(ΔCV) is the standard error of the change in coefficient of ~~variation~~variation, which is given by, $SE(\Delta CV) = \frac{CV^*}{(n_1 + n_2)^{\frac{1}{2}}}$

Where CV^* is the CV for the combined periods which is given by,

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$$CV^{*} = \frac{\{(n_1 - 1) \times CV_1 + (n_2 - 1) \times CV_2\}}{n_1 + n_2 - 2}$$ (Dash *et al.*, 2017)

n_1 and n_2 are number of observations in Period-I and Period-II respectively.

To decide on the direction of the changes (positive or negative) in CV, we perform one-tailed (right or left tailed) tests.

RESULTS AND DISCUSSION

Figures 1, 2 and 3 show the scatter plot of area, yield and production of rabi food grains in Odisha for the year 1993-94 to 2014-15. It is observed from the Figure 1 that the area under rabi food grains in Odisha shows an uneven decrease in the first 10 years and then shows constant increase in area ~~upto~~up to the last 12 years with slight increase in the last two years i.e. 2013-14 to 2014-15.

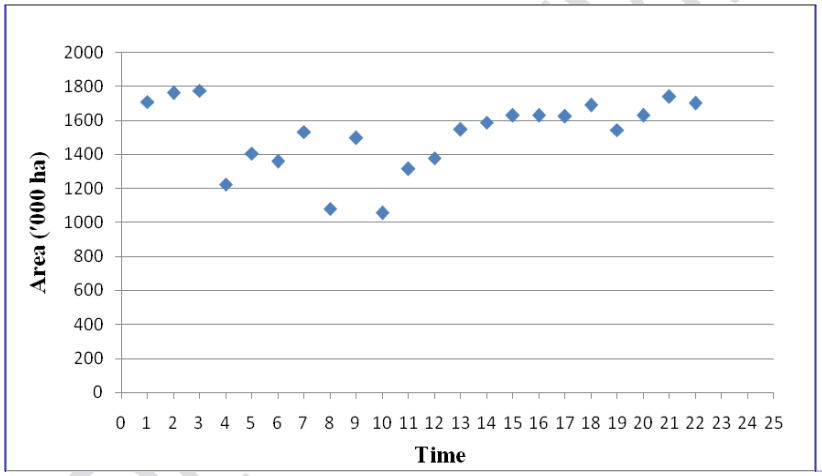
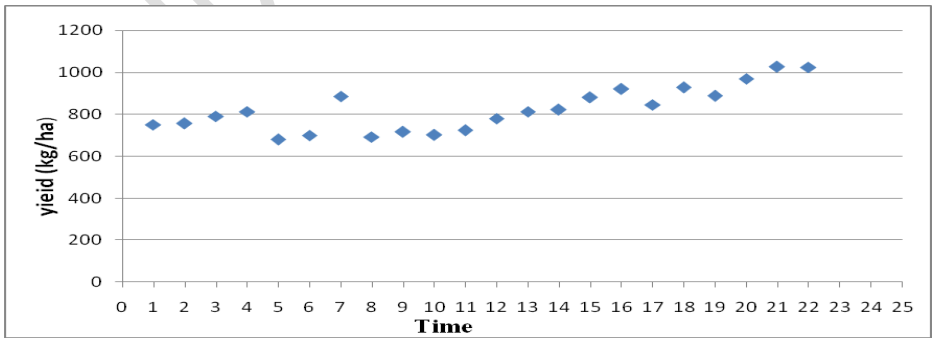


Figure 1: Scatter plot for area of rabi food grains in Odisha



It is seen from the Figure 2 that the yield of rabi food grains shows a slight decrease in the first 10 years of study period (1993-94 to 2002-03) with a sudden and irregular increase in

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the middle of first period i.e. in the year 1999-2000. Then after a steady increase in the yield of rabi food grains is marked in the period from 2003-04 to 2014-15.

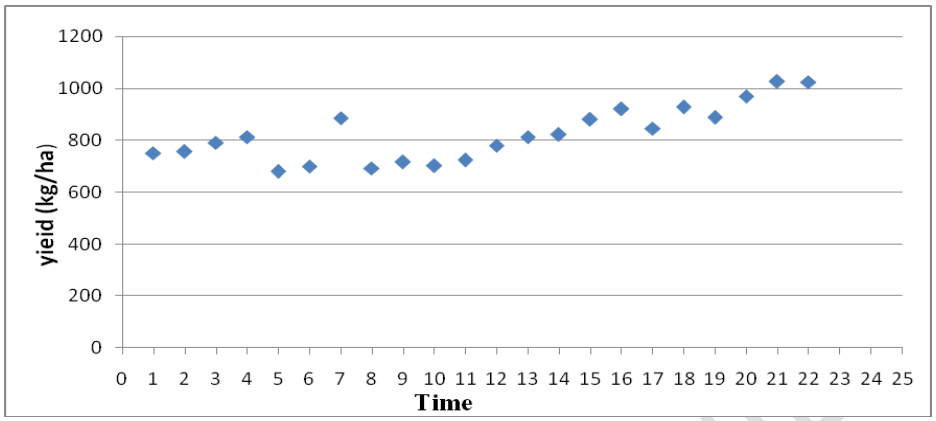

Figure 2: Scatter plot for yield of rabi food grains in Odisha

It is seen from the Figure 3 that the production of rabi food grains shows an uneven increase and decrease in the first 10 years of study period. After 10 years of study period it shows a constant increase in production of rabi food grains up to the year 2009-10 then shows slight increase and decrease in production up to the last years of study period.

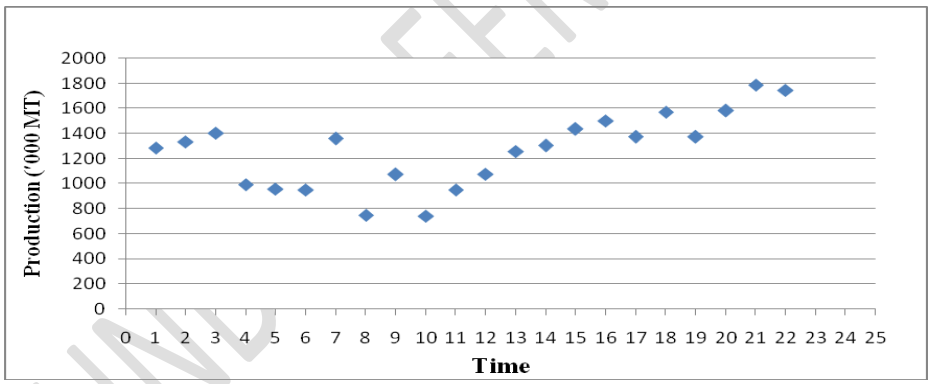

Figure 3: Scatter plot for production of rabi food grains in Odisha

On basis of scatter plot of the data on area, yield and production of rabi food grains in Odisha the entire period of study is divided into two periods i.e. period-I (1993-94 to 2002-03) and period-II (2003-04 to 2014-15) on basis of scatter plot.

Table 1 reveals that there is significant increase in mean yield and mean production of rabi food grains in Odisha where as there is no significant change in mean area from Period-I to Period-II.

Mean area in Bhadrak, Cuttack and Kendrapada districts show significant change whereas other coastal districts do not show any significant change. Mean yield show

significant increase in Balasore, Ganjam and Puri districts whereas it shows significant decrease in Cuttack, Jagatsingpur and Kendrapada districts. Mean production show significant decrease in Balasore and Jagatsingpur districts whereas it shows significant increase from Period-I to Period-II in Puri districts and in other coastal districts mean production don't show any significant change.

Table 1: Change in mean area, yield and production of rabi food grains from period-I (1993-94 to 2002-03) to period-II (2003-04 to 2014-15) in coastal districts of Odisha and the state as a whole.

Districts	Area (in '000 ha)			Yield (in Kg/ha)			Production (in '000 MT)		
	M_1	M_2	ΔM	M_1	M_2	ΔM	M_1	M_2	ΔM
Balasore	53.39	49.44	-3.96 (4.593)	1250.92	1847.3	596.38** (149.868)	65.6	92.3	26.7* (9.900)
Bhadrak	37.76	26.92	-10.84** (4.318)	887.94	958.84	70.89 (84.373)	33.48	26.74	-6.74 (5.931)
Cuttack	97.5	110.68	13.18* (5.934)	597.05	529.38	-67.67* (38.216)	57.25	58.6	1.35 (5.836)
Ganjam	169.27	190.63	21.36 (14.382)	441.23	487.27	46.04* (18.375)	73.69	93.47	19.78 (9.150)
Jagatsinghpur	48.4	53.57	5.17 (2.298)	613.1	469.68	-143.42** (58.339)	29.33	25.24	-4.1* (2.853)
Kendrapada	60.9	78.88	17.98* (4.943)	738.55	501	-237.55** (51.773)	43.72	39.49	-4.23 (4.007)
Khurdha	55.29	52.9	-2.39 (4.696)	584.49	611.98	27.49 (73.498)	33.53	32.76	-0.76 (5.529)
Puri	98.43	105.39	6.96 (9.541)	915.65	1160.36	244.71* (109.354)	90.02	121.47	31.45* (12.493)
Odisha	**1440.3**	**1584.6**	**144.25 (85.960)**	**749.18**	**885.62**	**136.45** ** **(35.297)**	**1084.9**	**1412.88**	**327.94** ** **(106.041)**

(Values in the parentheses indicates standard error)

M_1-Mean area/production/yield of period-I; M_2-Mean area/production/yield of period-II; $\Delta M = M_2 - M_1$

*-Significant at 5% level of significance; **- Significant at 1% level of significance

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Table 2 shows that, there is significant decrease in variance of area of rabi food grains of Odisha from Period-I to Period-II, but variance of yield and production do not show any significant change. Variance of area shows significant decrease in Balasore, Bhadrak, Cuttack and Puri districts, whereas, in the remaining districts, it shows no significant change from Period-I to Period-II. Yield variance show significant decrease in Cuttack, Jagatsingpur, Kendrapada and Khurdha districts from Period-I to Period-II and non-significant in other coastal districts of Odisha. In Cuttack, Jagatsingpur and Kendrapada districts, variance of production of rabi food grains show significant decrease from Period-I to Period-II.

Table 2: Change in variance of area, yield and production of rabi food grains from period-I (1993-94 to 2002-03) to period-II (2003-04 to 2014-15) in coastal districts of Odisha and the state as a whole.

Districts	Area (in '000 ha)			Yield (in Kg/ha)			Production (in '000 MT)		
	V_1	V_2	ΔV	V_1	V_2	ΔV	V_1	V_2	ΔV
Balasore	219.58	29.54	-190.04**	61161.25	172706.9	111545.7	318.27	711.63	393.36

Bhadrak	164.50	46.75	-117.76*	49129.54	31194.52	-17935	306.42	119.21	-187.22
Cuttack	354.01	34.79	-319.21**	16847.42	2048.248	-14799.2**	311.25	34.46	-276.78**
Ganjam	1476.65	560.66	-915.99	2127.56	1617.997	-509.56	518.78	313.56	-205.22
Jagatsinghpur	42.95	8.71	-34.24	45968.63	1821.535	-44147.1**	102.97	10.61	-92.364*
Kendrapada	184.39	6.26	-178.13	33151.51	1674.957	-31476.6**	192.54	10.19	-182.35**
Khurdha	182.82	74.22	-108.59	47492.19	15904.79	-31587.4*	260.35	98.55	-161.79
Puri	888.09	163.73	-724.36*	98698.28	43382.34	-55315.9	1259.45	497.93	-761.52
Odisha	70075.04	15946.93	-54128.1*	4260.53	8869.92	4609.39	61229.2	61420.4	191.18

V_1- Area/production/yield variance of period-I**; V_2-** Area/production/yield variance of period-II; **$\Delta V = V_2 - V_1$**
***-**Significant at 5% level of significance**; **-** Significant at 1% level of significance

Table 3 shows that change in coefficient of variation of area of rabi food grains of Odisha show significant decrease from Period-I to Period-II and change in C.V. of yield and production show no significant change from Period-I to Period-II. In Bhadrak and Jagatsingpur districts change in coefficient of variation of area of rabi food grains do not show significant change from Period-I to Period-II, whereas, other coastal districts show significant decrease in area of rabi food grains from Period-I to Period-II. In Cuttack, Jagatsingpur, Kendrapada, Khurdha and Puri districts, change in coefficient of variation of yield of rabi food grains show significant decrease from Period-I to Period-II, whereas, in Balasore, Bhadrak and Ganjam districts, it shows no significant change from Period-I to Period-II. In Cuttack, Ganjam, Kendrapada, Khurdha and Puri districts, change in coefficient of variation of production of rabi food grains show significant decrease and in remaining districts, it shows no significant change from Period-I to Period-II.

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Table 3: Change in Coefficient of Variation (C.V. %) of area, yield and production of rabi food grains from period-I (1993-94 to 2002-03) to period-II (2003-04 to 2014-15) in coastal districts of Odisha and the state as a whole.

~~(in per cent)~~

Districts	Area (CV, %)			Yield (CV,%)			Production (CV,%)		
	CV_1	CV_2	ΔCV	CV_1	CV_2	ΔCV	CV_1	CV_2	ΔCV
Balasore	27.752	10.994	-16.758**	19.77	22.497	2.726	27.195	28.902	1.707

			(3.952)			(4.535)			(5.998)
Bhadrak	33.352	25.071	-8.281 (6.140)	24.211	19.006	-5.205 (4.551)	46.225	41.708	-4.517 (9.325)
Cuttack	20.396	5.156	-15.241** (2.561)	19.228	9.886	-9.342** (3.004)	31.109	11.464	-19.644** (4.329)
Ganjam	24.224	13.558	-10.666* (3.914)	10.68	8.029	-2.651 (1.966)	31.978	19.92	-12.058* (5.404)
Jagatsinghpur	12.083	9.228	-2.855 (2.241)	30.535	11.579	-18.956** (4.287)	27.801	18.47	-9.331 (4.833)
Kendrapada	21.288	12.995	-8.293* (3.566)	22.911	8.877	-14.034** (3.239)	27.604	12.624	-14.98** (4.129)
Khurdha	24.454	15.548	-8.906* (4.169)	36.983	19.861	-17.123** (5.877)	46.98	29.229	-17.751* (7.935)
Puri	29.511	13.338	-16.173** (4.395)	34.129	17.16	-16.968** (5.287)	39.358	19.043	-20.315** (6.009)
Odisha	**18.379**	**7.969**	**-10.409** (2.698)**	**8.713**	**10.634**	**1.922 (2.083)**	**22.807**	**17.541**	**-5.267 (4.245)**

(Values in the parentheses indicates standard error)
CV_1- Area/production/yield coefficient of variation of period-I
CV_2- Area/production/yield coefficient of variation of period-II; **$\Delta CV = CV_2 - CV_1$**
*-Significant at 5% level of significance**; ****-** Significant at 1% level of significance

SUMMARY AND CONCLUSIONS

The study of scatter diagrams of area, yield and production of rabi food grains of Odisha reveals that certain change is observed after 10^{th} year of study period i.e. after 2002-03. So the whole period of study is divided into two periods on the basis of change in scatter plot data. Change in mean yield and mean production of rabi food grains of Odisha show significant increase from period-I to period-II. Mean production show significant decrease in Balasore and Jagatsingpur districts and in Puri districts, mean production of rabi food grains show significant increase from Period-I to Period-II.

Significant decrease in variance of area of rabi food grains of Odisha is marked from Period-I (1993-94 to 2002-03) to Period-II (2003-04 to 2014-15) but variance of yield and production do not show any significant change.

In Cuttack, Jagatsingpur and Kendrapada districts, variance of production of rabi food grains show significant decrease from Period-I to Period-II. Change in coefficient of variation of area of rabi food grains of Odisha show significant decrease from Period-I (1993-94 to 2002-03) to Period-II (2003-04 to 2014-15).

In the districts like Bhadrak, Ganjam and Kendrapada, change in coefficient of variation of area show significant decrease from Period-I to Period-II. Contribution of yield and area effect towards change in mean production of rabi food grains is 59.93% and 32.95% respectively.

From the overall study, it is observed that, in case of rabi food grains of Odisha, significant increase in mean production from Period-I to Period-II is due increase in mean yield from Period-I to Period-II.

The variability in production of rabi food grains has increased for Odisha and for all the coastal districts except Balasore in Period-II as compared to period-I. This increase in variability might be due to uneven irrigation.

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