International Journal of Agriculture, Environment and Biotechnology
Citation: *IJAEB*: **14**(03): 349-355, September 2021
DOI: 10.30954/0974-1712.03.2021.10

ASSOCIATION FOR AGRICULTURE ENVIRONMENT AND BIOTECHNOLOGY

AGRICULTURAL ECONOMICS

Instability and Decomposition Analysis of Sesamum Crop Production in Karnataka and India

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Paper No. 919 **Received:** 14-06-2021 **Revised:** 25-08-2021 **Accepted:** 03-09-2021

ABSTRACT

Sesamum is one of the oldest oilseed crops generally grown in Africa and Asia for its high-quality nutritional value. The instability in sesamum production was examined by employing instability index. At all India level, the instability in sesamum area and production has increased from Period I to Period II and it declined in Period III. Interestingly the instability in productivity of sesamum has marginally declined from Period I to Period II and from Period II to Period III. In the case of Karnataka state, in area and production instability of sesamum has increased from Period I to Period II and to Period III. Further, the study conducted a decomposition analysis to determine the contribution of different components to the sesamum production. The results of the decomposition of change in average sesamum production in India as well as in Karnataka shows, change in mean area and interaction between mean area and mean yield influencing change in average production of sesamum in overall period. Among the ten constituents of change in variance of production of sesamum, change in area variance is the dominant reason for instability in sesamum production. In Karnataka, change in area variance contributed maximum to change in variance of production in all the four periods, followed by interaction between changes in mean yield and area variance. The study findings suggest the need for research efforts to concentrate on production techniques, improve productivity, and developing varieties with higher productivity potential, wider adaptability, application of improved crop protection techniques, and capacity building for expertise in agronomic practices will have a vital role in providing modern system of sesame production in India.

HIGHLIGHTS

- Instability of area, production and yield of sesamum has been discussed for India and Karnataka.
- Change in mean area and interaction between mean area is the predominant component contributing to change in average production of sesamum in India.
- There is a need for research efforts to concentrate on production techniques, improve productivity, and developing varieties

Keywords: Growth, Instability, Production, Area

India is fortunate in having a variety of oilseed crops grown in its distinctive rich agro climatic zones. India ranks fifth in world vegetable oil economy, next to USA, China, Brazil and Argentina. The two main interventions, which have significantly contributed to the enhancement of the oilseed sector in India are Technology Mission on Oilseeds (TMO) called Oilseeds Production Programme (OPP) initiated by the Govt of India in May 1986, during 8th five-year plan, in order to enhance the oilseed production in the nation and liberalisation of trade in oilseeds in the post-WTO period.

How to cite this article: Nayak, A., Lokesha, H., Gracy, C.P. and Geetha, K.N. 2021. Instability and Decomposition Analysis of Sesamum Crop Production in Karnataka and India. *IJAEB*, **14**(03): 349-355.

Source of Support: None; **Conflict of Interest:** None

The TMO launched special initiatives on several critical fronts such as improvement of oilseed production and processing technology, additional support to oilseed farmers and processors and enhanced customs duty on the import of edible oils and also programme was designed to supplement the efforts of the state governments' for enhancing the production and productivity of various oilseed crops such as groundnut, soybean, safflower, sunflower, sesamum, rapeseed/mustard, castor, linseed and Niger seeds.

Sesame (*Sesamum indicum* L.) is one of the oldest oilseed crops widely grown in Africa and Asia for its high-quality nutritional benifits. Sesamum belongs to the family Pedaliaceae. Worldwide, it is used for its nutritional, medicinal, and industrial purposes. It is called 'sesame' internationally, while it is called 'benni seed' in West Africa; 'simsim' in East Africa and 'Till' in India. These seeds are commonly used to garnish bakery products, certain confectionary products, crackers, chips, vegetarian foods and oriental specialities. Historically, the sesame seed was referred to as the "queen of oilseeds," and sesame oil is among the first oils known and consumed by man.

It is perhaps the oldest annual oilseed crop known to man. India is believed to be the centre of origin of the crop (Brar and Ahuja 1979). Sesamum oil contains 83–90 per cent unsaturated fatty acids, 20 per cent proteins, various minor nutrients. Globally, India is the leading consumer, producer and exporter of sesame. India ranks first in the world with respect to area under sesame cultivation. The area under sesame is 1,419.97 thousand hectares with a production of 689.31 thousand tonnes and an average yield of 485 kg per hectare during 2018-19. Sesame is grown predominantly in West Bengal, Uttar Pradesh, Rajasthan, Madhya Pradesh, Andhra Pradesh, Maharashtra, Gujarat, Tamil Nadu, Karnataka and Orissa. In most of the other states, it is grown as a minor crop. Because of competition from other edible oil seeds such as soybean, sunflower, peanut and of low productivity it could not manage its ranking over other oilseed crops in the country.

Keeping in view of the present scenario of sesamum cultivation in the country an attempt was made here to focus on sesamum prospects for India as a whole and Karnataka state in terms of magnitude of production instability along with instability in acreage expansion & yield over three decades and in overall period. Simultaneously the components of change in the average production of sesamum as well as variance of production of sesamum are addressed in this paper.

MATERIALS AND METHODS

The study is based on secondary data gathered from published sources of the India stat. The study pertains to Karnataka state and India as a whole. In view of the limitation of the data, the present study is restricted for a period of 48 years from 1971-72 to 2018-19 for analytical purpose. However, for better understanding of growth performance of sesamum crop and for instability analysis of growth in area, production and productivity were computed before and after introduction of Technology Mission on Oilseeds for the period from 1971-72 to 2018-19 which was further bifurcated into three sub periods *viz*., Period-I (1971-72 to 1986-87), Period-II (1987-88 to 2002-03) and Period-III (2003-04 to 2018-19).

Instability Analysis

Instability analysis depicts the uncertainty with the help of indicators like Coefficient of variation, Standard deviation and instability index, etc. The instability in area, production and productivity of groundnut was analysed using the method proposed by Ray (1983).

Instability index = Standard deviation of natural logarithm (Y_{t+1}/Y_t)

Where,

Y_t is the area/production /yield in the current year and Y_{t+1} is for the next year.

This index is unit free and it measures deviations from the underlying trend.

The instability of sesamum in India as well as Karnataka was analysed using the Cuddy- Della Valle index. This is a commonly used index to measure the magnitude of instability in exports and imports (Cuddy and Della Valle 1978). It is a better measure compared to coefficient of co-variation as it is inherently adjusted for trend, often observed in time series data.

The formula is given as follows:

$$I_x = \frac{SD}{\overline{Y}}\sqrt{1-R^2} \times 100$$

Where,

I_x = Instability index,

SD = Standard Deviation

$\overline{Y}$ = Average value of the time series data

R^2 = Coefficient of multiple determination obtained from the time series.

Hazell's decomposition method

The model of decomposition was developed by Peter, B.R. Hazell in 1982. This model was primarily developed to analyze the instability in Indian cereal production. This method is one among the most common methods of decomposition used till now. In this model, average production and variance of production are decomposed into several components. This model is mainly used for the time series data.

Model

Let Q be the production, A be the area and Y be the yield. Then for each crop, Q = A*Y. The average production can be expressed as,

$$E(Q) = \overline{A}\overline{Y} + Cov(A,Y) \quad \ldots(1)$$

Where, $\overline{A}$ and $\overline{Y}$ indicates the mean area and mean yield (Nayak, 2021).

These sources include the changes in mean area ($\Delta\bar{A}$), changes in mean yield ($\Delta\overline{Y}$), the interaction between changes in mean area and mean yield ($\Delta\bar{A}\Delta\overline{Y}$) and the changes in the variability of area and yield ($\Delta Cov(A,Y)$ (Hazell, 1982). These components of change in average production are arranged in Table 1.

The change in the variance of production can also be decomposed in the analogous way. Taking the variance of production and applying the variance formula leads to the decomposition as shown in Table 2. Here also the results are obtained by taking first period as the base.

Ten sources of change in variance in output is identified. The components 1, 2, 5 and 6 represents the sources of change in mean output change can also occur through changes in variance of area, yield and the interaction between them.

Among the ten constituents of change in variance of production, the first four represents the pure effect and are immense importance from variability point of view. The fifth component contributes towards the interaction effect, which is the outcome of simultaneous occurrence in change in mean area and yield. Sixth component represents the change in variability in area, yield and from changes in correlation between area and yield. The seventh and the eighth components refer to second and third degree interaction between changes in mean area, yield and also the variability in them. The last two sources of change are not significant in the present context.

RESULTS AND DISCUSSION

It could be observed from Table 3 that in the case of India, the instability in sesamum area has increased from Period I (5.2%) to Period II (9.6%) and thereafter declined in Period III (8.7%). Similarly, the instability in production of sesamum also increased from Period I (13.7%) to Period II (17.6%) and further declined in Period III (13.2%). Interestingly the instability in productivity of sesamum has marginally declined from Period I (13.7%) to Period II (12.2%) and from Period II to Period III (10.8%). In overall period, the instability in area, production and productivity of sesamum was 10.1, 16.1 and 12.3 per cent, respectively.

In Karnataka state, the instability in area under sesamum has increased from Period I (9.9%) to Period II (28.3%) and to Period III (70.3%). Similarly, the instability in production of sesamum also increased substatically from Period I (21.6%) to Period II (30.6%) and to Period III (74.7%). The corresponding instability in productivity of sesamum was 15.20 per cent for Period I, 22.50 per cent in Period II and 19.80 per cent in Period III. The overall period instability in area, production and productivity of sesamum stands at 52, 58.7 and 25 per cent, respectively. The magnitude of instability is alarming as it reflects shifts in area and yield variability.

The results of decomposition of change in average sesamum production in India are presented in Table 4. It is evident from the table that during period I, change in area-yield co-variance acted as

Table 1: Components of change in average production

Sl. No.	Sources of Change	Symbol	Component of change
1	Change in mean yield	$\Delta\bar{Y}$	$\bar{A}_I\Delta\bar{Y}$
2	Change in mean area	$\Delta\bar{A}$	$\bar{Y}_I\Delta\bar{A}$
3	Interaction between change in mean area and mean yield	$\Delta\bar{Y},\Delta\bar{A}$	$\Delta\bar{Y},\Delta\bar{A}$
4	Change in area – yield Covariance	$\Delta Cov\ (A,Y)$	$\Delta Cov\ (A,Y)$

Source: *Hazell, 1982.*

Table 2: Components of change in variance of production

Sl. No.	Source of changes	Symbol	Components of Change (Percentage)
1	Change in mean yield	$\Delta\bar{Y}$	$2(\bar{A}_I\Delta\bar{Y}CoV\ (A_I,Y_I) +[2_I\bar{Y}_I\Delta\bar{Y} -(\Delta\bar{Y})^2]V(A_I))$
2	Change in mean area	$\Delta\bar{A}$	$2\bar{Y}_{II}\Delta\bar{A}Cov(A_I, Y_I)+[2\bar{A}_I\Delta\bar{A}-(\Delta\bar{A})^2]V(Y_I)$
3	Change in yield variance	$\Delta V(Y)$	$(\bar{A}_I)^2\Delta V(Y)$
4	Change in area variance	$\Delta V(A)$	$(_I)^2\Delta V(A)$
5	Interaction between changes in mean yield and mean area	$\Delta\bar{Y},\Delta\bar{A}$	$2\Delta\bar{Y}\Delta\bar{A}CoV(Y_I, A_I)$
6	Change in area-yield covariance	$\Delta Cov\ (A,Y)$	$[2\bar{A}_I\bar{Y}_I-2CoV(Y_I, A_I)]\Delta CoV-[\Delta CoV(A, Y)]^2$
7	Interaction between changes in mean area and yield variance	$\Delta\bar{A},\Delta V(Y)$	$[2_I\Delta+ (\Delta)^2]\Delta V(Y)$
8	Interaction between changes in mean yield and area variance	$\Delta\bar{A},\Delta V(A)$	$[2\bar{A}_I\Delta\bar{Y}+(\Delta\bar{Y})^2]\Delta V(A)$
9	Interaction between changes in mean area and yield and change in area-yield covariance	$\Delta\bar{A},\Delta\bar{Y},\Delta Cov\ (A,Y)$	$[2\bar{Y}_I\Delta\bar{A}+2\bar{A}_I\Delta\bar{Y} +2\Delta\bar{A}\Delta\bar{Y}]\ \Delta CoV(A,Y)$
10	Change in residual	ΔR	$\Delta V(A, Y)$ − sum of other components

Source: *Hazell, 1982.*

Table 3: Instability in area, production and productivity of sesamum in India and Karnataka

	Periods	Instability index (%)		
		Area	Production	Productivity
India	I Period (1971-72 to 1986-87)	5.2	13.7	13.7
	II Period (1987-88 to 2002-03)	9.6	17.6	12.2
	III Period (2003-04 to 2018-19)	8.7	13.2	10.8
	Overall Period (1971-72 to 2018-19)	10.1	16.1	12.3
Karnataka	I Period (1971-72 to 1986-87)	9.9	21.6	15.2
	II Period (1987-88 to 2002-03)	28.3	30.6	22.5
	III Period (2003-04 to 2018-19)	70.3	74.7	19.8
	Overall Period (1971-72 to 2018-19)	52.0	58.7	25.0

Table 4: Components of change in the average production of sesamum in India

Sl. No.	Sources of change		Components of Change (%)			
	Description	Symbol	I Period	II Period	III Period	Overall Period
1	Change in mean yield	$\Delta\bar{Y}$	-02.94	-00.01	00.16	-00.02
2	Change in mean area	$\Delta\bar{A}$	-381.35	95.52	96.9	87.43
3	Interaction between change in mean area and mean yield	$\Delta\bar{A}, \Delta\bar{Y}$	-07.34	03.95	06.9	12.61
4	Change in area-yield co-variance	$\Delta Cov(A,Y)$	491.63	00.53	-04.11	-00.01
	Total		**100**	**100**	**100**	**100**

a major source of growth in average production of sesamum in India. Whereas in period II, III and for whole period, change in mean area and interaction between change in mean area and mean yield acted as major source of production growth. The overall period exhibited change in mean area and interaction between mean area and mean yield influencing change in average production of sesamum in India.

The results presented in Table 5 depicts that among the ten constituents of change in variance of sesamum production of change in area variance in all the periods, followed by interaction between changes in mean yield and area variance contributed more towards instability. The components such as change in mean area and interaction between changes in mean area and mean yield contributed towards stability in changes in variance of production of sesamum in India. Thus, from the study it could be concluded that change in area variance is the dominant reason for instability in sesamum production.

The results on different components of change in the average production of sesamum in Karnataka revealed that change in mean area and interaction between change in mean area and mean yield were the major components of change in average production of sesamum (Table 6). In overall period, the variability in production is the compound result of fluctuations in productivity and area.

It is revealed from Table 7 that among the components of change in variance of production of Sesamum in Karnataka, change in area variance contributed maximum to change in variance of production in all the four periods, followed by

Table 5: Components of change in variance of sesamum production in India

Sl. No.	Sources of change		Components of Change (%)			
	Description	**Symbol**	**I Period**	**II Period**	**III Period**	**Overall Period**
1	Change in mean yield	$\Delta\bar{Y}$	0.00	0.00	0.00	0.01
2	Change in mean area	$\Delta\bar{A}$	0.01	4.25	0.55	-51.11
3	Change in yield variance	$\Delta V(Y)$	0.00	0.00	0.00	0.00
4	Change in area variance	$\Delta V(A)$	99.75	95.42	99.04	133.95
5	Interaction between changes in mean area and mean yield	$\Delta\bar{Y},\Delta\bar{A}$	0.00	0.18	0.04	-7.37
6	Change in yield - area covariance	$\Delta Cov\ (A,Y)$	-0.02	0.024	-0.023	0.008
7	Interaction between changes in yield variance and mean area	$\Delta\bar{A},\Delta V(Y)$	0.00	-0.00	-0.00	-0.06
8	Interaction between changes in area variance and mean yield	$\Delta\bar{Y},\Delta V(A)$	1.92	3.95	7.12	19.32
9	Interaction between changes in mean yield and area and change in area-yield covariance	$\Delta\bar{A},\Delta\bar{Y},\Delta Cov(A,Y)$	-0.00	-0.56	-0.07	-0.68
10	Change in residual	ΔR	-1.66	-3.25	-6.64	5.93
	Total		**100**	**100**	**100**	**100**

Table 6: Components of change in the average production of sesamum in Karnataka

Sl. No.	Sources of change		Components of Change (%)			
	Description	**Symbol**	**I Period**	**II Period**	**III Period**	**Overall Period**
1	Change in mean yield	$\Delta\bar{Y}$	-00.04	-00.06	00.66	-00.09
2	Change in mean area	$\Delta\bar{A}$	103.64	93.54	79.82	92.86
3	Interaction between change in mean area and mean yield	$\Delta\bar{A},\ \Delta\bar{Y}$	-01.33	04.27	13.84	06.99
4	Change in area-yield co-variance	$\Delta Cov(A,Y)$	-02.26	02.26	5.67	00.23
	Total		**100**	**100**	**100**	**100**

Table 7: Components of change in variance of sesamum production in Karnataka

Sl. No.	Sources of change		Components of Change (%)			
	Description	**Symbol**	**I Period**	**II Period**	**III Period**	**Overall Period**
1	Change in mean yield	$\Delta\bar{Y}$	0.01	0.01	0.04	0.01
2	Change in mean area	$\Delta\bar{A}$	-11.59	-6.00	4.46	-15.31
3	Change in yield variance	$\Delta V(Y)$	0.00	0.00	0.00	0.00
4	Change in area variance	$\Delta V(A)$	108.01	96.28	74.29	108.40
5	Interaction between changes in mean area and mean yield	$\Delta\bar{Y},\Delta\bar{A}$	0.15	-0.27	0.77	-1.15
6	Change in yield - area covariance	$\Delta Cov\ (A,Y)$	0.25	-0.15	0.32	-0.04
7	Interaction between changes in yield variance and mean area	$\Delta\bar{A},\Delta V(Y)$	0.03	-0.03	0.04	-0.178
8	Interaction between changes in area variance and mean yield	$\Delta\bar{Y},\Delta V(A)$	-1.39	4.39	12.88	8.16
9	Interaction between changes in mean yield and area and change in area-yield covariance	$\Delta\bar{A},\Delta\bar{Y},\Delta Cov(A,Y)$	-0.10	0.47	1.16	0.23
10	Change in residual	ΔR	4.64	5.30	6.04	-0.14
	Total			**100**	**100**	**100**

interaction between changes in mean yield and area variance. Karnataka exhibited positive area effect in all the crops including groundnut, sunflower, safflower, soybean and sesame (Nagarjun 2016).

CONCLUSION

Instability is one of the important decision parameters in development dynamics and more so in the context of agriculture production. Instability in area, production and yield of sesamum has been discussed in both India and Karnataka.

At all India level, the instability in sesamum area and production has increased from Period I to Period II and it declined in Period III. The instability in productivity of sesamum has marginally declined from Period I to Period II and from Period II to Period III. In the case of Karnataka state, the instability in area and production under sesamum has increased from Period I to Period II and to Period III.

The results of the decomposition of change in average sesamum production in India and Karnataka shows, change in mean area and interaction between mean area and mean yield influencing change in average production of sesamum in India in overall period. Among the ten constituents of change in variance of production of sesamum, the change in area variance is the dominant reason for instability in sesamum production. In Karnataka, change in area variance contributed maximum to change in variance of production in all the four periods, followed by interaction between changes in mean yield and area variance. The study findings suggest the need for research efforts to concentrate on production techniques, improve productivity, and developing varieties with higher productivity potential, wider adaptability, application of improved crop protection techniques, and capacity building for expertise in agronomic practices will have vital role in providing modern sesame production systems in India.

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