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Growth and instability analysis of linseed for major selected districts in Chhattisgarh

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Abstract
The study investigates the growth and instability analysis of linseed for major selected districts in Chhattisgarh based on secondary data on the area, production, and productivity of linseed. Linseed is one of the important non-edible oilseeds utera crop of Chhattisgarh. The compound annual growth rate of the area and production in selected districts of Chhattisgarh from 2001-02 to 2022-23 reveals that the linseed was found negative growth with low to moderate instability in area and production, while linseed yield shows a positive growth rate. It highlights the fact that the area under the linseed is shrinking.

Keywords: Linseed, CGR, instability

Introduction
Linseed or flaxseed (*Linum usitatissimum* L., 2n = 30, X = 15) belongs to the order Malpighiales, the family Lineceae, and the tribe Lineae is one of the oldest cultivated crops grown for seed and fiber. The studies undertaken by research workers at various times mostly related to cereals and pulses crops like paddy, wheat, chickpea, and Lathyrus very limited work has been done on linseed which is the major oilseed crop of Chhattisgarh. Thus, is with the above consideration in view, that the present study has been taken up to analyze the trends in the production of linseed in Chhattisgarh.

Linseed is the principal oilseed crop grown in Chhattisgarh under utera in rainfed conditions. It occupies 34% share of the total oilseed production in the state and 17% in India. The higher area is reported from the states of Rajasthan (4.43 lakh ha), Madhya Pradesh (2.70 lakh ha), Chhattisgarh (0.64 lakh ha), Odisha (0.56 lakh ha), west Bengal (0.55 lakh ha) and less area is reported from the other state**.** Chhattisgarh ranks fourth in the country concerning area and production of linseed (MP > JHA > UP > CG) (A/C to Ministry of Agriculture and Farmers Welfare).

Flaxseed is one of the world’s richest known plant sources of Omega-3. Flax oil is widely used in the industry for the manufacture of soaps, paints, varnishes, vanaspati oil, cloth, linoleum, printing ink, and oil cakes are used as cattle feed and manures. Linseed is used in making paper and plastic. Fibers obtained from the stem are known for their length and strength and are two to three times as strong as those of cotton. (A/C to AICRP of Linseed and Mustard, Akola 2014)

Methods and Materials
The detailed sampling procedure was adopted to accomplish the specified objectives of the present study.

Chhattisgarh state is made up of a total of 33 districts, which out of 5 districts Balrampur, Sarguja, Surajpur (Northern Hill Zone), Rajnandgaon (Chhattisgarh Plain Zone) and Kanker (Bastar Plateau Zone) district were selected for the study purpose. For area, production and productivity data collected for the last 22 years that is from the year 2001-02 to 2022-23 for all the selected districts.

Time series secondary data on area, production, and productivity of linseed were collected from various sources published by the Government of Chhattisgarh, Directorate of Economics and Statistics, Chhattisgarh, Directorate of Agriculture and Statistical Abstract of Chhattisgarh State.

Analytical tools
The collected data were analyzed by using the following tools and techniques to achieve the specific objectives of the study.

Trend
Trend analysis for area, production, and productivity was estimated with the help of a linear equation. The linear trend was fitted with the method of least square technique.

$Y = a + bx$

Where,
Y = Trend value of a dependent variable (Area, Production, and Yield)
x = Independent variable (Time in Year)
b = Regression / Trend coefficient
a = Intercept / Constant

Linear growth rate (LGR)

$LGR = b/ \bar{Y} \times 100$

Where,
b = Regression / Trend coefficient
a = Intercept / Constant
$\bar{Y}$ = Mean of dependent variable

Estimation of compound growth rate in area, production, and yield
The growth in area, production, and productivity of linseed was using the exponential growth function of the form-

$Y = ab^t$

Where,
Y = Trend value (Area, Production, and Yield)
a = Constant
b = Trend coefficient
t = Independent variable (Time in Year)

Compound growth rate
The compound growth rate per annum over the period for all the variables was calculated from the following formula-
C.G.R. (%) = [Antilog of b – 1] × 100

Instability index
To measure the instability in area, production, and productivity an index of instability was used as a measure of variability (Ramoliya et al.). The Cuddy Della Valle Index (CDVI) is calculated as follows-

$CDVI = CV*\sqrt{(1 - R^2)}$

$CV (\%) = \frac{\text{Standard deviation} \times 100}{\text{Mean}}$

Where,
CV = Coefficient of variation
R^2 = Coefficient of multiple determination

The ranges of CDVI (Sihmar, 2014) [19] are given as follows
Low instability = between 0 and 15
Medium instability = greater than 15 and lower than 30
High instability = greater than 30

Results and Discussion
Instability analysis for the area of linseed in the major producing district in Chhattisgarh
Instability is dependent on the CV. The availability of quality seeds of improved varieties is one of the major constraints limiting linseed productivity. The instability of the agriculture sector depends on climatic factors subjected to a large degree of uncertainty, and it is said that growth with stability is good but growth with instability is a lot of facts. Generally, a growth rate is not able to explain fluctuations or instability in the time series data, so the coefficient of Variation (CV) was used as a measure of instability in area, production, and productivity. The results are presented in below Table 1.
In terms of production, High instability was found in the Kanker district during Period I, period II, and Period III, and moderate instability in production was found in Period II except for the Kanker district. Low and moderate instability in production was found for the Rajnandgaon district in period II. Moderately instability was found in Period I, period II, and Period III in another remaining selected district of Chhattisgarh.
The area and productivity of linseed were found in a similar trend in terms of instability. Moderate instability was found in all periods for the selected district of Chhattisgarh, except low instability was found in period II for the Surajpur district of Chhattisgarh. Overall, the moderate instability was found in Chhattisgarh.

Table 1: Period-wise instability analysis of the area under linseed

Particular	Period – I (2001-2011)		Period – II (2012-2022)		Period – III (2001-2022)	
	CV%	CDVI	CV%	CDVI	CV%	CDVI
AREA						
Rajnandgaon	40.85	7.54	45.51	12.20	80.93	26.51
Kanker	23.63	31.91	71.75	30.60	63.04	25.89
Sarguja	2.97	1.82	12.29	7.60	57.02	25.51
Balrampur	-	-	22.67	11.00	-	-
Surajpur	-	-	27.46	11.97	-	-
Production						
Rajnandgaon	39.11	13.46	48.52	23.93	72.43	25.09
Kanker	31.91	30.59	86.07	31.31	64.38	36.78
Sarguja	16.64	16.40	17.90	17.51	48.04	23.77
Balrampur	-	-	31.93	19.88	-	-
Surajpur	-	-	31.49	19.01	-	-
Productivity						
Rajnandgaon	16.52	15.39	22.17	21.54	23.85	19.25
Kanker	21.57	20.81	27.68	21.17	24.99	24.97
Sarguja	17.44	16.62	22.08	20.75	26.45	19.46
Balrampur	-	-	20.03	19.13	-	-
Surajpur	-	-	12.43	12.11	-	-

CV – Coefficient of variation, CDVI – Cuddy Vella instability index

Compound annual growth rate for area, production, and yield of linseed in major producing district of Chhattisgarh
The area, production, and yield of linseed from period I to period III were furnished in Table 2. It was observed that there was a negative trend in the area and production of linseed for all selected districts of Chhattisgarh in period I, period II, and period III, except the production of the Sarguja district in period I. In period I, period II, and period III yield recorded a positive trend in all districts except

Kanker and Balrampur districts with a negative trend in period II and period III respectively.

The CAGR of the area, production, and yield of linseed in the period I to period III were worked out and presented in Table 2. For periods I and II, the linseed area observed the highest growth rate of Sarguja after that Kanker and Rajnandgaon. In period II, linseed area registered the highest growth rate of Sarguja (-2.99%), Balrampur (-6.22%), Surajpur (-7.47%), Rajnandgaon (-12.80%) and Kanker (-19.71%). The null hypothesis was conspicuous in that all districts were significant at a 1% probability level for all periods except the Kanker district was non-significant for period I.

The linseed production observed the highest growth rate of Sarguja after Kanker and Rajnandgaon for period I and for period III highest growth rate of Sarguja followed by Kanker and Rajnandgaon. In period II, linseed production registered the highest growth rate of Sarguja (-1.11%) followed by Surajpur (-7.33%), Balrampur (-7.79%), Rajnandgaon (-11.69%) and Kanker (-23.77%). Overall null hypothesis was conspicuous in that all districts were significant at a 1% probability level for all periods except Kanker district was non-significant for period I and the Sarguja district was non-significant for period I and period II.

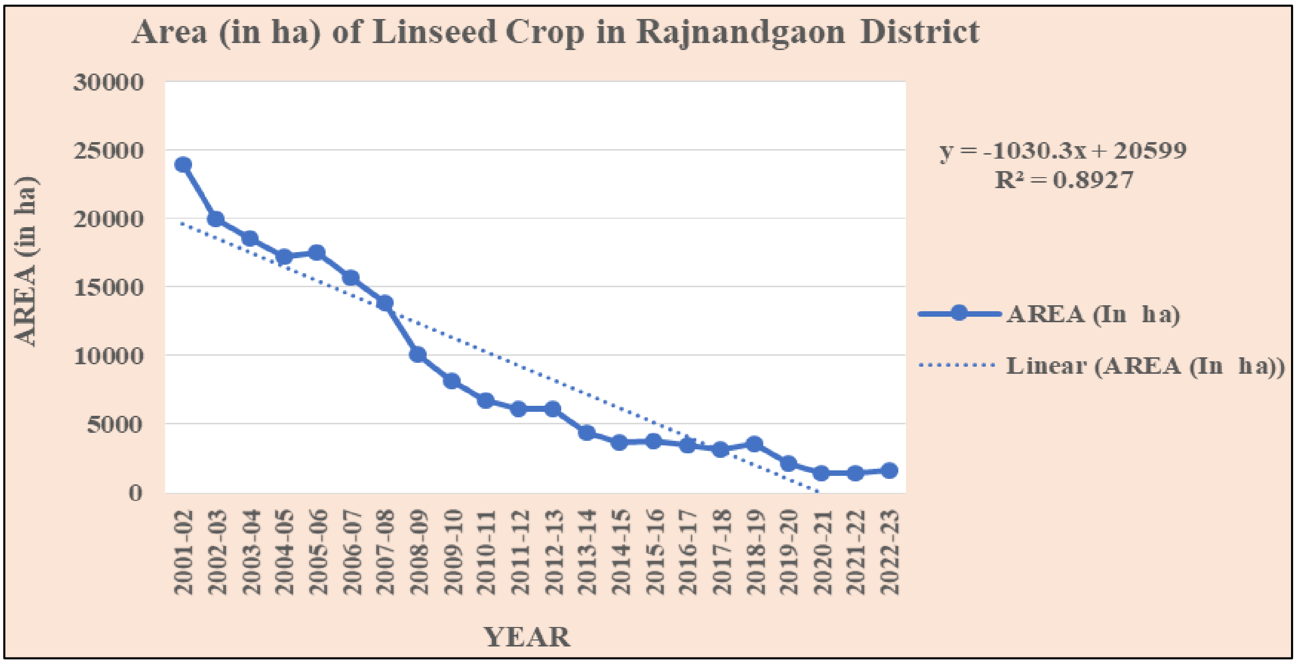
Linseed yield was observed as the highest growth rate of Sarguja after Rajnandgaon and Kanker for period I and period III. In period II, linseed production registered the highest growth rate of Sarguja (2.63%) followed by Surajpur (0.79%), Rajnandgaon (0.53%), Balrampur (-1.74%) and Kanker (-5.08%). Concluded that the null hypothesis was conspicuous in that there was non-significant of all districts for all periods except Kanker district was significant at a 5% probability level for period II and Rajnandgaon and Sarguja were significant at a 1% probability level for period II.

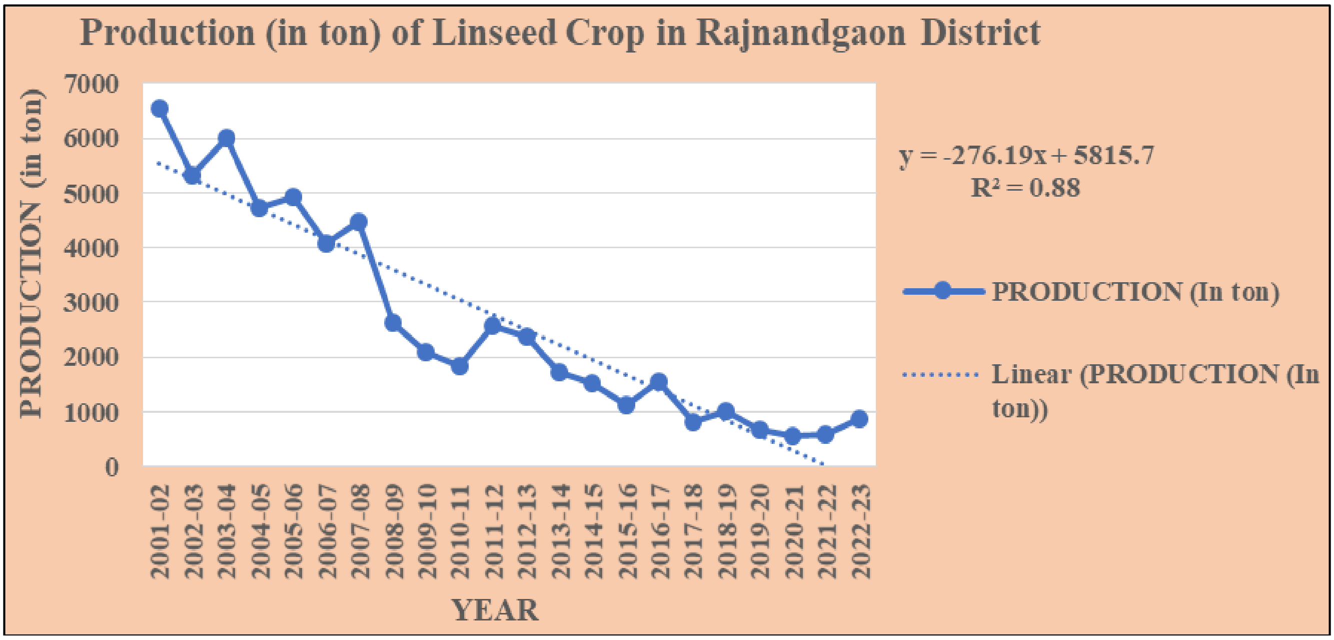
Table 2: Compound annual growth rate of area, production, and productivity of linseed in major producing district in Chhattisgarh

Particular	Period – I (2001-2011)		Period – II (2012-2022)		Period – III (2001-2022)	
	LGR	CGR	LGR	CGR	LGR	CGR
AREA						
Rajnandgaon	-12.11	-12.68***	-12.74	-12.80***	-11.77	-12.90***
Kanker	-3.32	-3.31 NS	-19.57	-19.71***	-8.85	-12.01***
Sarguja	-0.71	-0.70***	-2.91	-2.99***	-7.82	-8.66***
Balrampur	-	-	-5.98	-6.22***	-	-
Surajpur	-	-	-7.45	-7.47***	-	-
Production						
Rajnandgaon	-11.07	-11.40***	-12.73	-11.69***	-10.46	-11.12***
Kanker	-2.74	-1.27 NS	-23.3	-23.77***	-8.14	-11.86***
Sarguja	0.85	0.67 NS	-1.11	-1.11 NS	-5.80	-6.26***
Balrampur	-	-	-7.53	-7.79***	-	-
Surajpur	-	-	-7.57	-7.33***	-	-
Productivity						
Rajnandgaon	1.81	1.48NS	1.58	0.53NS	2.17	2.03***
Kanker	1.72	2.20 NS	-5.38	-5.08**	0.86	0.21 NS
Sarguja	1.60	1.39NS	2.28	1. 95NS	2.75	2.63***
Balrampur	-	-	-1.79	-1.74 NS	-	-
Surajpur	-	-	0.85	0.79NS	-	-

LGR – Linear growth rate, CGR – Compound growth rate

Note: *** denote significant at 1% level of significant (p<.01), ** denote significant at 5% level of significant (P < .05) and NS denote not-significant





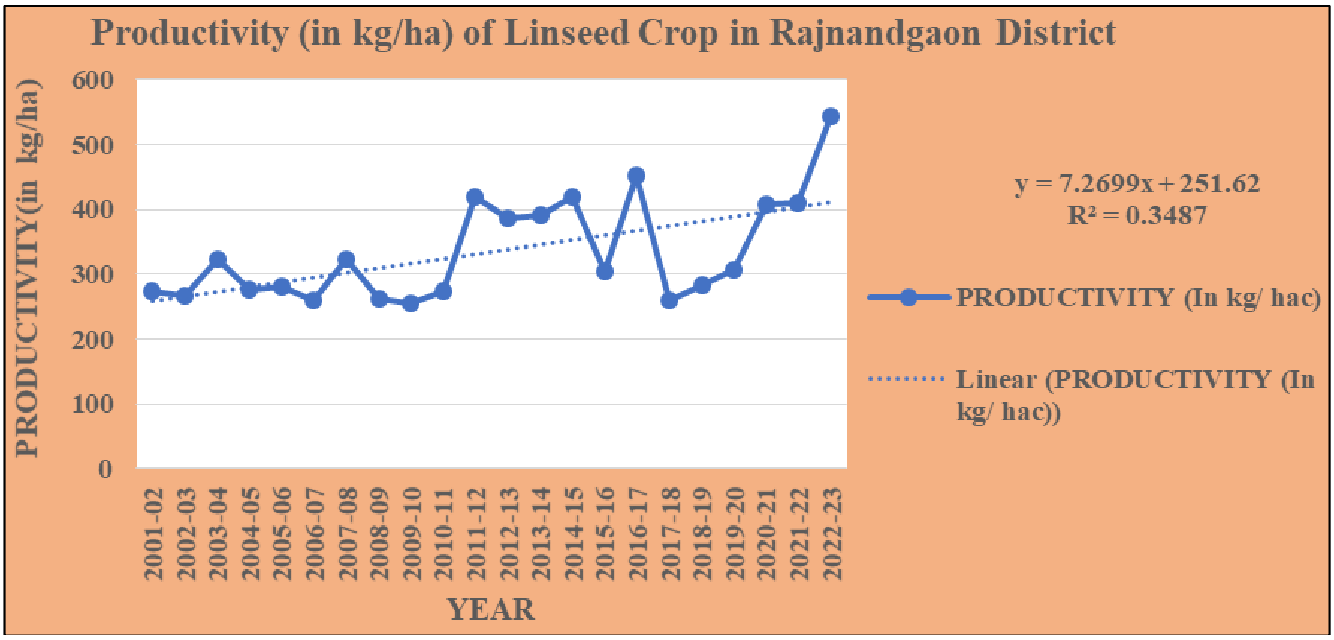


Fig 1: CGR of (a) Area (b) Production and (c) Productivity of Linseed Crop in Rajnandgaon District

In Fig. 1 (a) equation was represented, R^2- 0.89 indicates that about 89 percent of the variation in area is explained by year.

Regression equation: The intercept term, 20599 ha. represents the estimated linseed area of India, when the year was zero. The coefficient of x variable i.e. β = -1030.3 ha. indicates the rate of change in area for each unit increase in the year. In this case, it suggests a decrease of 1030.3 ha. units in the area for each year increase**.**

So, this equation suggests that the area of linseed decreases over the years, starting from an initial value of 20599 ha.

In Fig.1 (b) equation was represented**,** R^2- 0.88 indicates that about 88 percent of the variation in production is explained by year.

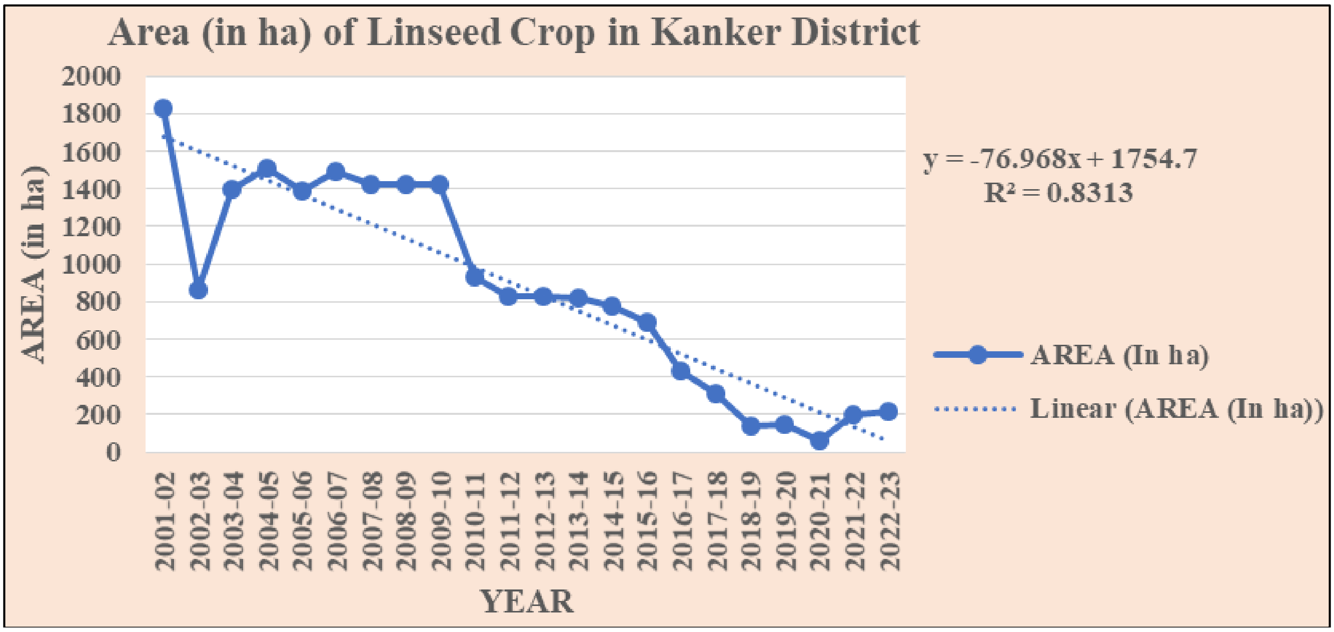
Regression equation: The intercept term 5815.7 tonnes, represents the estimated linseed production of India when the year was zero. The coefficient of x variable i.e. β = -276.19 ton. indicates the rate of change in production for each unit increase in the year. In this case, it suggests a decrease of 276.19 tons. units in production for each year increase**.**

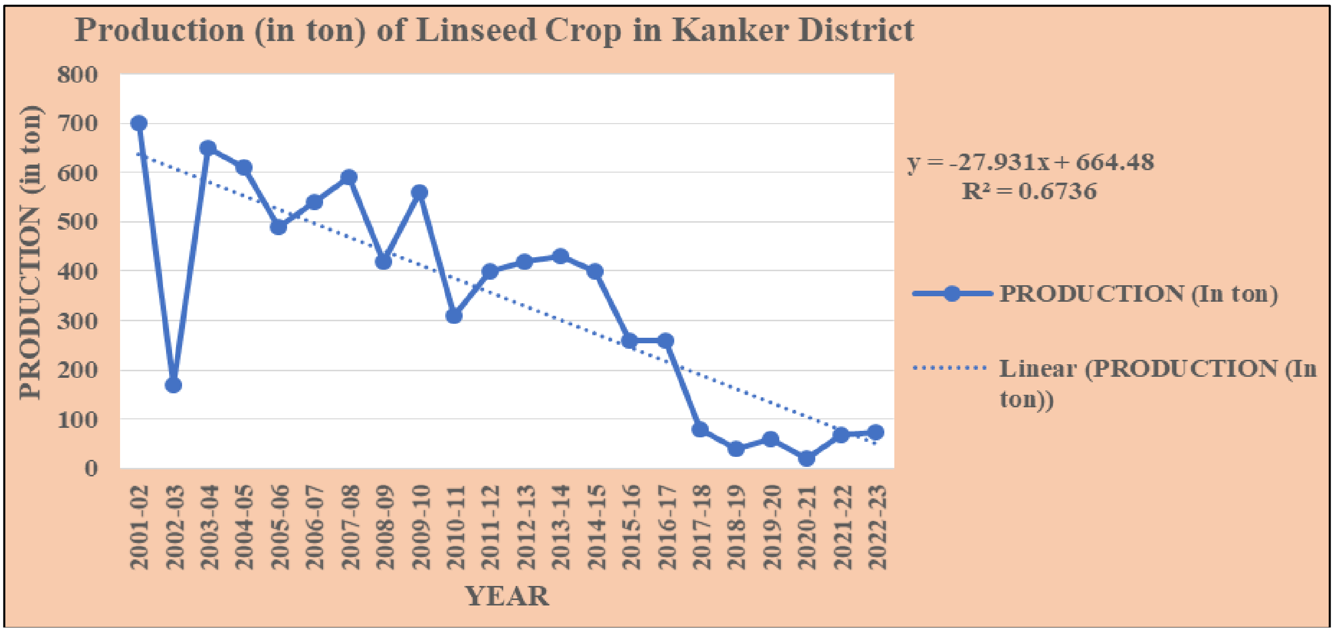
So, this equation suggests that the production of linseed decreases over the years, starting from an initial value of 5815.7 tons.

In Fig.1 (c) equation was represented R^2- 0.34 indicating that about 34 percent of the variation in productivity is explained by year.

Regression equation: The intercept term, 251.62 kg/ha, represents the estimated linseed productivity of India when the year was zero. The coefficient of x variable i.e. β = 7.27 kg/ha. indicates the rate of change in productivity for each unit increase in the year. In this case, it suggests an increase of 7.27 kg/ha. units in productivity for each year increase**.**

So, this equation suggests that the productivity of linseed increases over the years, starting from an initial value of 251.62 kg/ha.





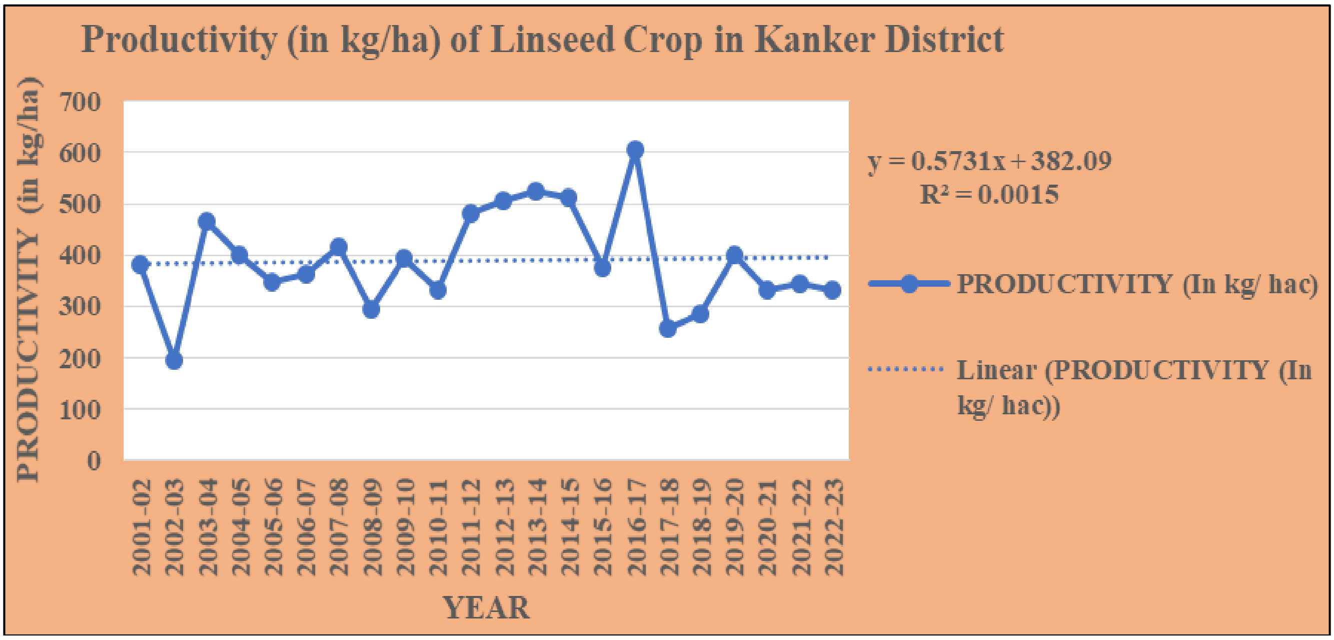


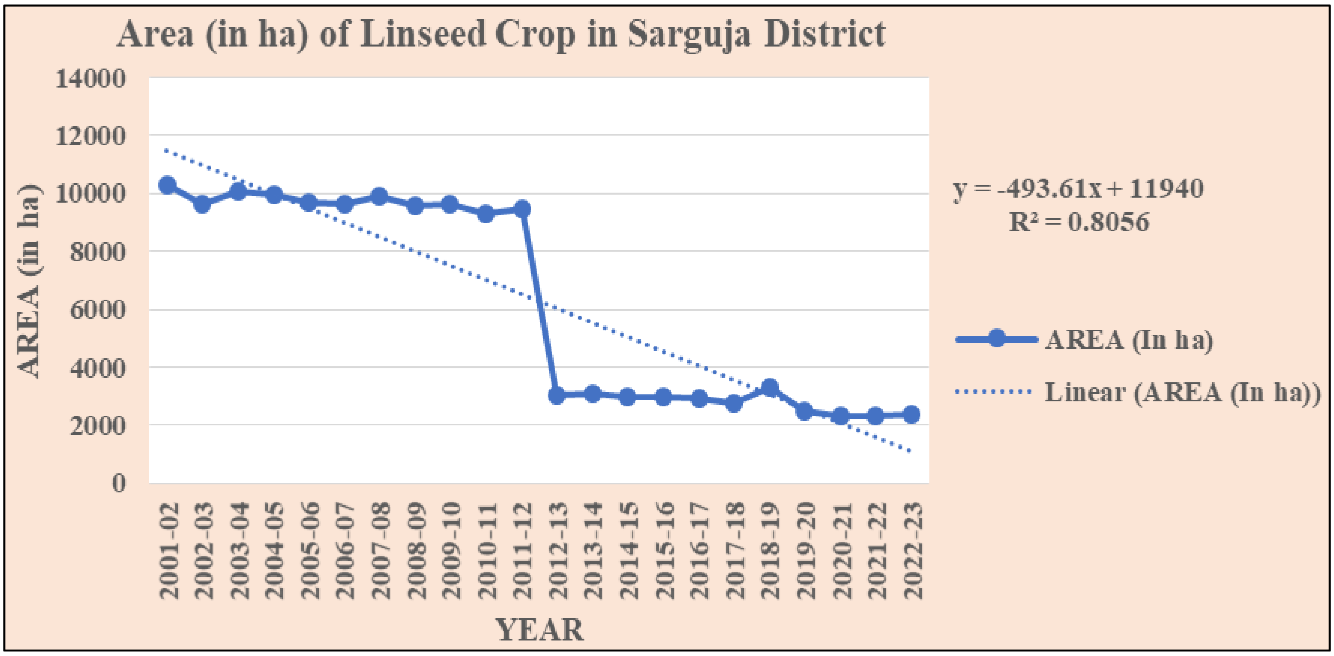
Fig 2: CGR of (a) Area (b) Production and (c) Productivity of Linseed Crop in Kanker District

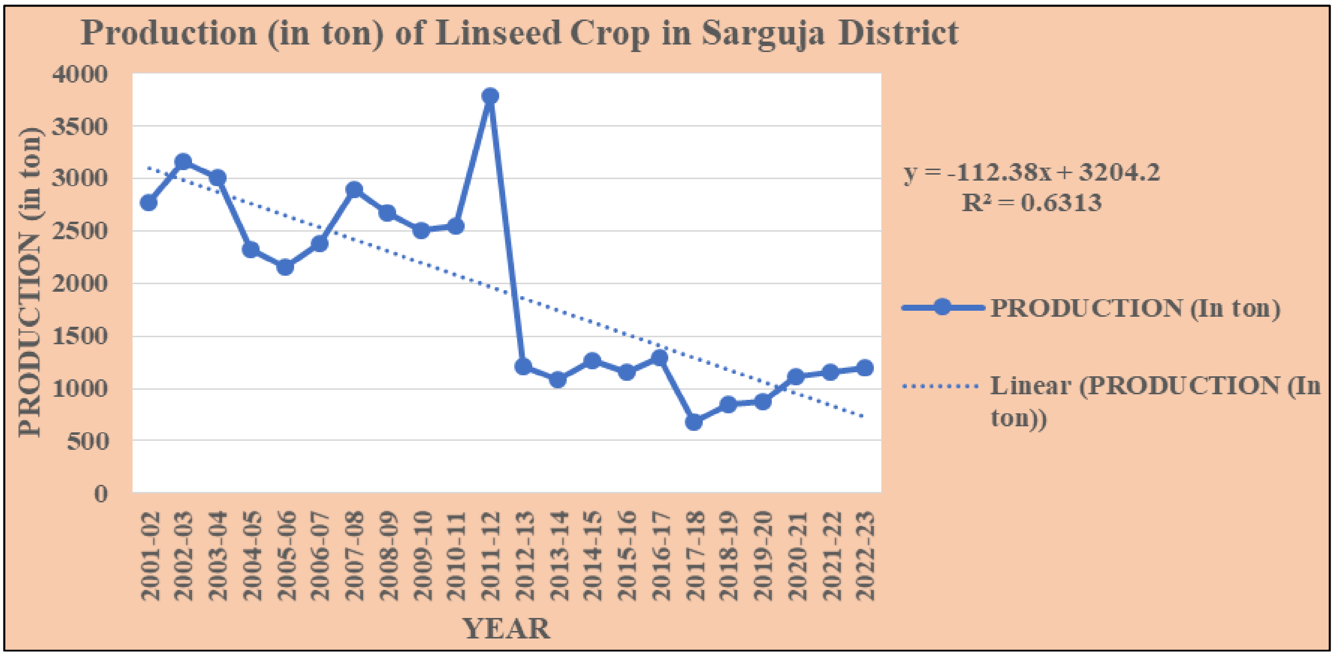
In Fig.2 (a) equation was represented, R^2- 0.83 indicates that about 80 percent of the variation in the area is explained by year.

Regression equation: The intercept term, 1754.7 ha. represents the estimated linseed area of India, when the year was zero. The coefficient of the x variable i.e. β = -76.968 ha. indicates the rate of change in area for each unit increase in the year. In this case, it suggests a decrease of 76.968 ha. units in the area for each year increase**.**
So, the equation suggests that the area of linseed decreases over the years, starting from an initial value of 1754.7 ha.
In Fig. 2 (b) equation was represented by R^2- 0.67 indicating that about 67 percent of the variation in the production is explained by year.

Regression equation: The intercept term 664.48 tonnes, represents the estimated linseed production of India when the year was zero. The coefficient of the x variable i.e. β = -27.93 ton. indicates the rate of change in production for each unit increase in the year. In this case, it suggests a decrease of 27.931 tons. units in production for each year increase**.**
So, the equation suggests that the production of linseed decreases over the years, starting from an initial value of 664.48 tons.
In Fig. 2 (c) equation was represented by R^2- 0.0015 indicating that about 0.1 percent or minute variation in the area is explained by year.

Regression equation: The intercept term, 382.09 kg/ha, represents the estimated linseed productivity of India when the year was zero. The coefficient of the x variable i.e. β = 0.5731 kg/ha. indicates the rate of change in productivity for each unit increase in the year. In this case, it suggests an increase of 0.5731 kg/ha. units in productivity for each year increase**.**
So, the equation suggests that the productivity of linseed increases over the years, starting from an initial value of 382.09 kg/ ha.





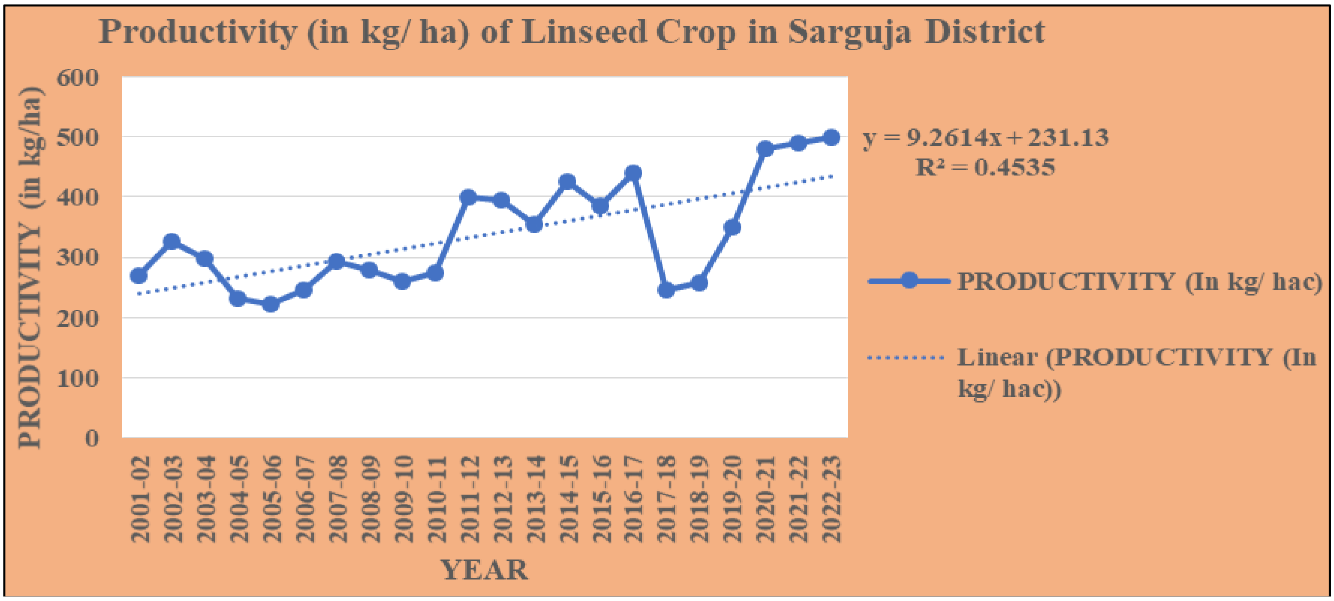


Fig 3: CGR of (a) Area (b) Production and (c) Productivity of Linseed Crop in Sarguja District

In Fig. 3 (a) equation was represented, R^2- 0.80 indicates that about 80 percent of the variation in area is explained by year.

Regression equation: The intercept term, 11940 ha, represents the estimated linseed area of India when the year was zero. The coefficient of x variable i.e. β = -493.61 ha. indicates the rate of change in area for each unit increase in the year. In this case, it suggests a decrease of 493.61 ha. units in the area for each year increase**.**

So, this equation suggests that the area of linseed decreases over the years, starting from an initial value of 11940 ha.

In Fig. 3 (b) equation was represented by R^2- 0.63 indicating that about 63 percent of the variation in production is explained by year.

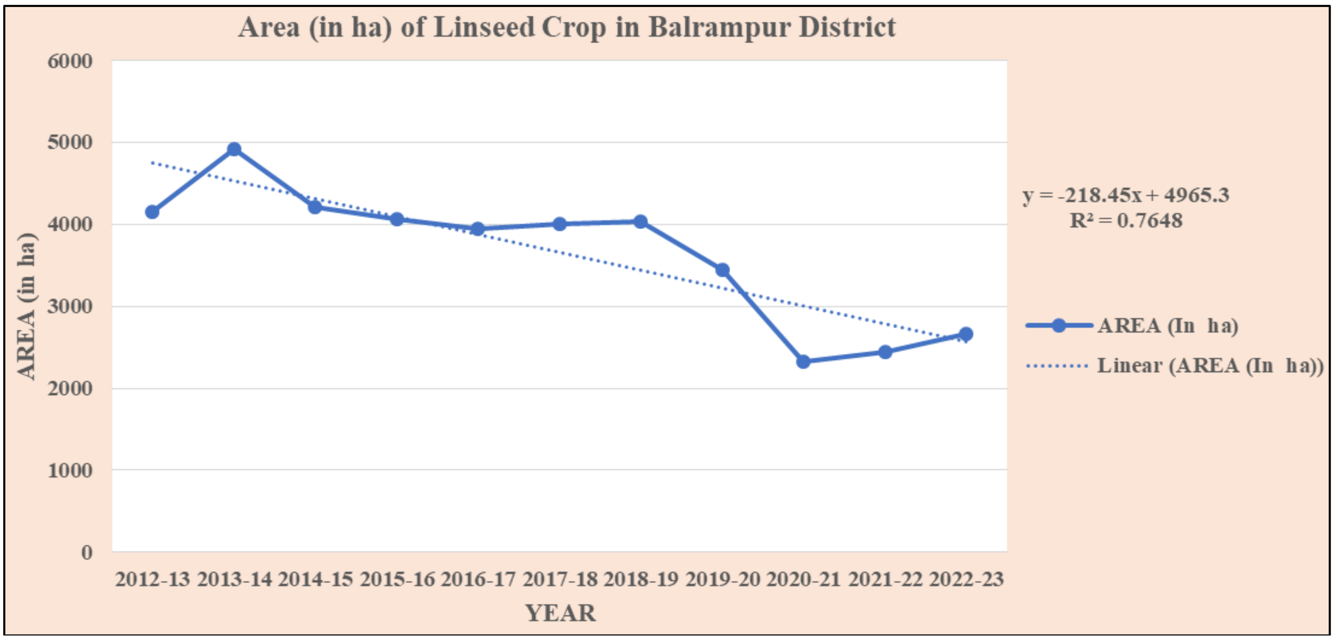
Regression equation: The intercept term 3204.2 tonnes, represents the estimated linseed production of India when the year was zero. The coefficient of x variable i.e. β = -112.38 ton. indicates the rate of change in production for each unit increase in the year. In this case, it suggests a decrease of 112.38 tons. units in production for each year increase**.**

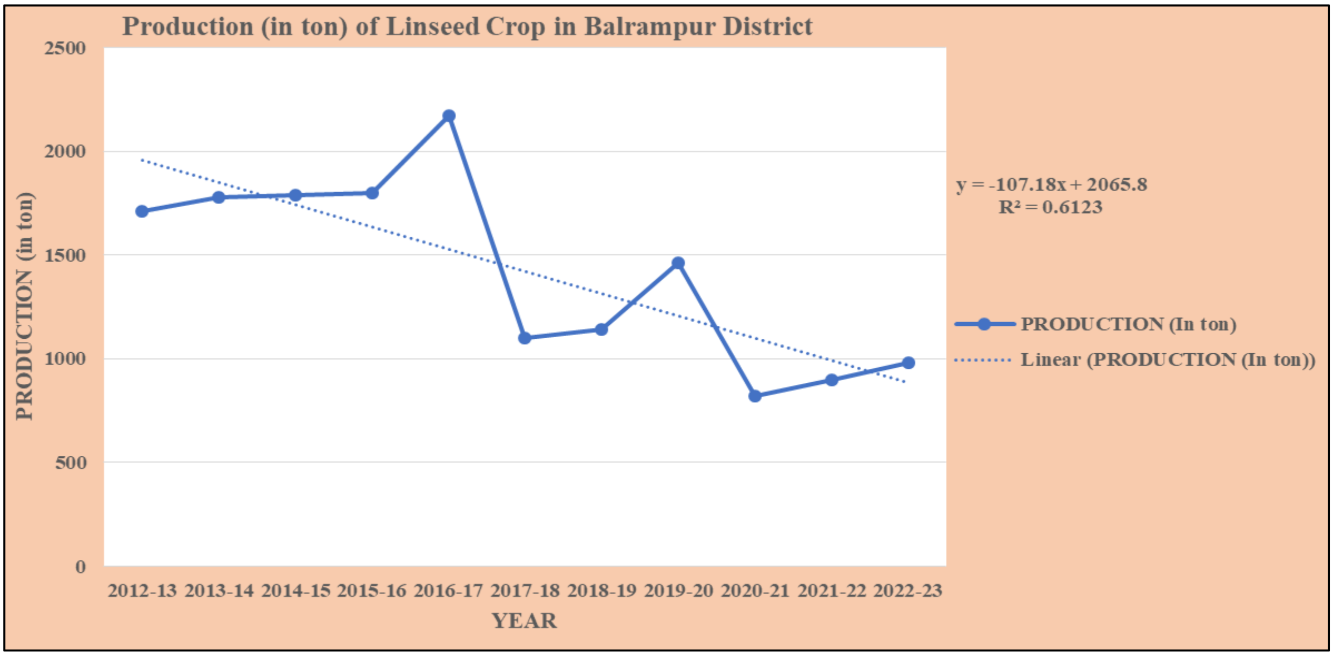
So, this equation suggests that the production of linseed decreases over the years, starting from an initial value of 3204.2 tons.

In Fig. 3 (c) equation was represented **by** R^2- 0.45 indicating that about 45 percent of the variation in productivity is explained by year.

Regression equation: The intercept term, 231.13 kg/ha, represents the estimated linseed productivity of India when the year was zero. The coefficient of x variable i.e. β = 9.261 kg/ha. indicates the rate of change in productivity for each unit increase in the year. In this case, it suggests an increase of 9.261 kg/ha. units in productivity for each year increase**.**

So, this equation suggests that the productivity of linseed increases over the years, starting from an initial value of 231.13 kg/ha.





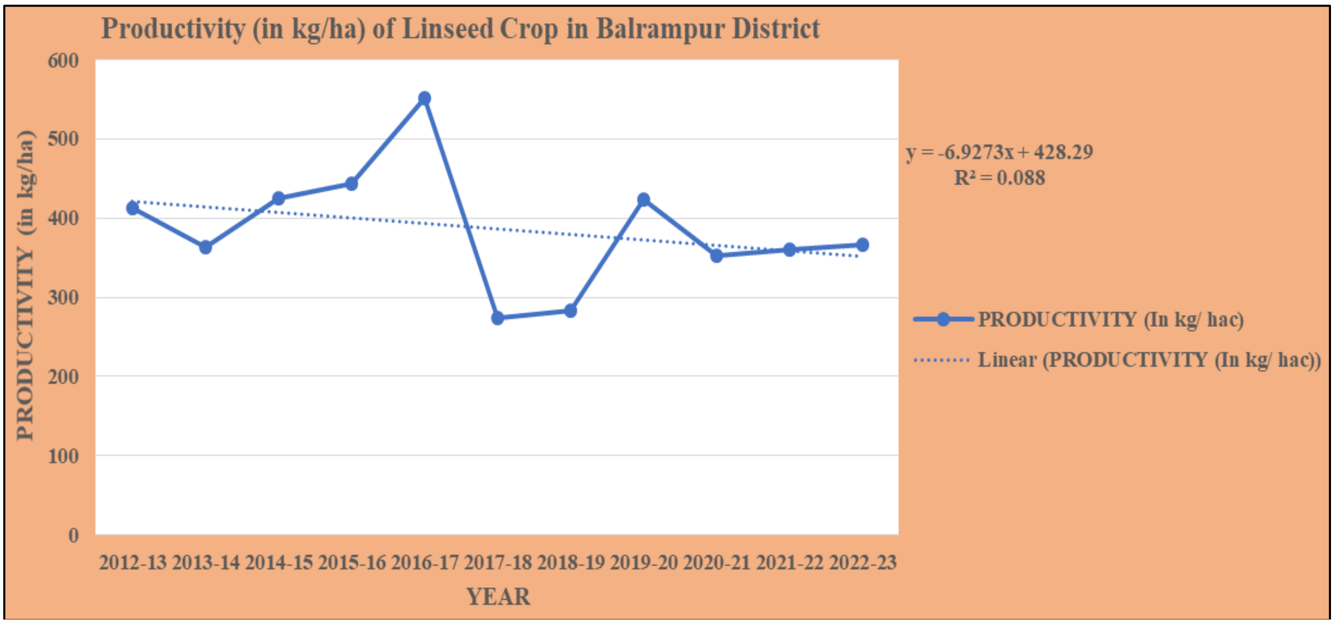


Fig 4: CGR of (a) Area (b) Production and (c) Productivity of Linseed Crop in Balrampur District

In Fig. 4 (a) equation was represented, **R^2**- 0.76 indicates that about 76 percent of the variation in area is explained by year.

Regression equation: The intercept term, 4965.3 ha. represents the estimated linseed area of India, when the year was zero. The coefficient of x variable i.e. β = -218.45 ha. indicates the rate of change in area for each unit increase in the year. In this case, it suggests a decrease of 218.45 ha. units in the area for each year increase**.**

So, this equation suggests that the area of linseed decreases over the years, starting from an initial value of 4965.3.

In Fig. 4 (b) equation was represented, R^2- 0.61 indicates that about 61 percent of the variation in production is explained by year.

Regression equation: The intercept term 2065.8 tonnes, represents the estimated linseed production of India when the year was zero. The coefficient of x variable i.e. β = -107.18 ton. indicates the rate of change in production for each unit increase in the year. In this case, it suggests a decrease of 107.18 tons. units in production for each year increase**.**

So, this equation suggests that the production of linseed decreases over the years, starting from an initial value of 2065.8 tons.

In Fig. 4 (c) equation was represented, R^2- 0.088 indicates that about 0.8 percent of the variation in productivity is explained by year.

Regression equation: The intercept term, 428.29 kg/ha, represents the estimated linseed productivity of India when the year was zero. The coefficient of the x variable i.e. β = 6.92 kg/ha. indicates the rate of change in productivity for each unit increase in the year. In this case, it suggests an increase of 6.92 kg/ha. units in productivity for each year increase.

So, this equation suggests that the productivity of linseed increases over the years, starting from an initial value of 428.29 kg/ha.

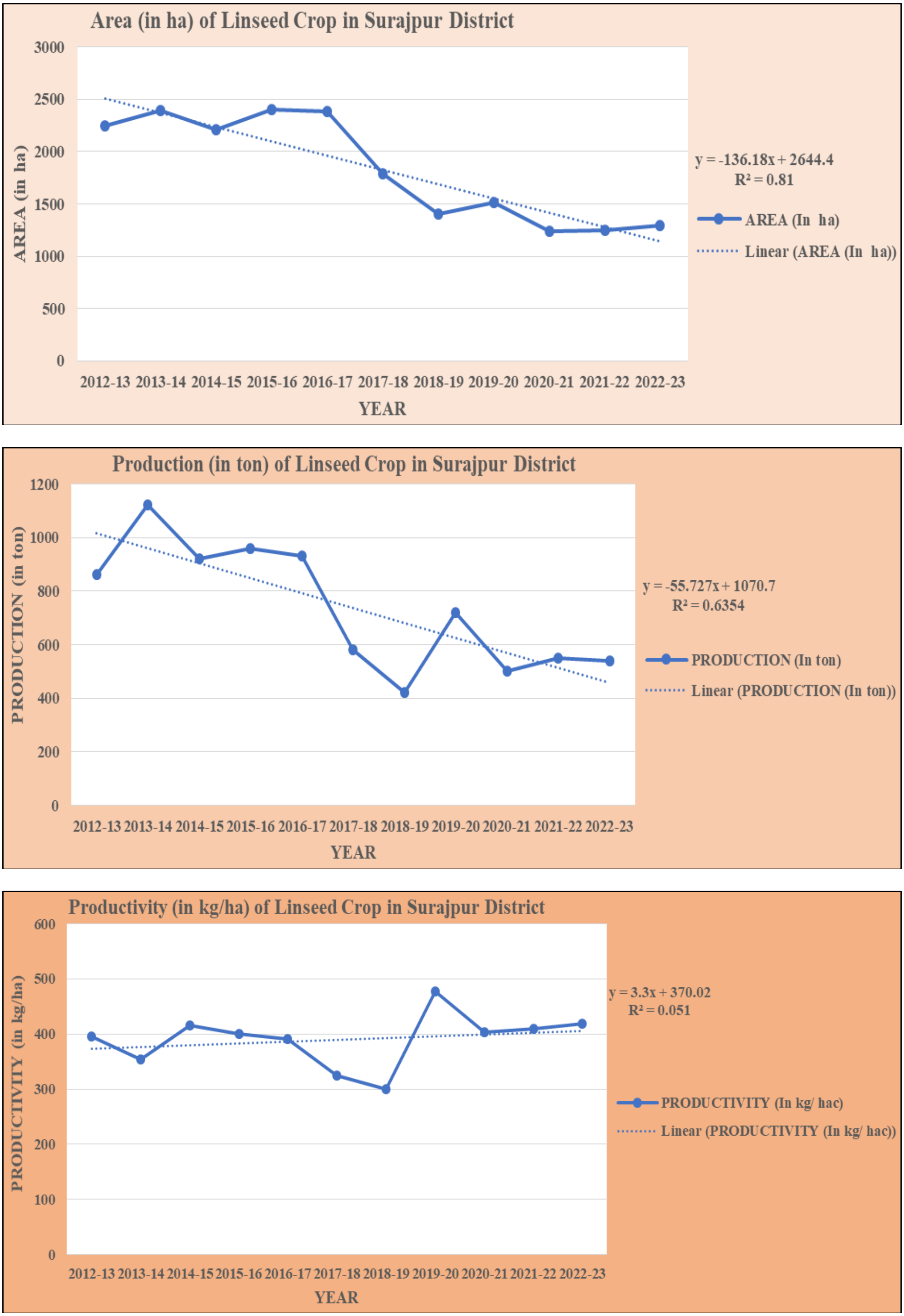


Fig 5: CGR of (a) Area (b) Production and (c) Productivity of Linseed Crop in Surajpur District

In Fig. 5 (a) equation was represented, R^2- 0.81 indicates that about 81 percent of the variation in area is explained by year.

Regression equation: The intercept term, 2644.4 ha. represents the estimated linseed area of India, when the year was zero. The coefficient of x variable i.e. β = -136.18 ha. indicates the rate of change in area for each unit increase in the year. In this case, it suggests a decrease of 136.18 ha. units in the area for each year increase**.**
So, this equation suggests that the area of linseed decreases over the years, starting from an initial value of 2644.4 ha.
In Fig. 5 (b) equation was represented, R^2- 0.63 indicates that about 63 percent of the variation in production is explained by year.

Regression equation: The intercept term 1070.7 tonnes, represents the estimated linseed production of India when the year was zero. The coefficient of x variable i.e. β = -55.72 ton. indicates the rate of change in production for each unit increase in the year. In this case, it suggests a decrease of 55.72 tons. units in production for each year increase**.**
So, this equation suggests that the production of linseed decreases over the years, starting from an initial value of 1070.7 tons.
In Fig. 5 (c) equation was represented, R^2- 0.051 indicates that about 0.5 percent of the variation in productivity is explained by year.

Regression equation: The intercept term, 370.02 kg/ha, represents the estimated linseed productivity of India when the year was zero. The coefficient of x variable i.e. β = 3.3 kg/ ha. indicates the rate of change in productivity for each unit increase in the year. In this case, it suggests an increase of 3.3 kg/ha. units in productivity for each year increase**.**
So, this equation suggests that the productivity of linseed increases over the years, starting from an initial value of 370.02 kg/ha.

Conclusion and Suggestions

Research conducted by various workers has primarily focused on cereal and pulses crops such as paddy, wheat, chickpea, and lathyrus with limited attention given to linseed, linseed is the primary non-edible oilseed crop of Chhattisgarh. Relative changes in area and production of linseed were found negative for all selected districts while relative changes for the yield were observed positive for the selected districts of Chhattisgarh Rajnandgaon, Sarguja, and Surajpur except Kanker and Balrampur districts of Chhattisgarh. Moderately instability was found in the area for the selected district of Chhattisgarh, except low instability was found in the Balrampur and Surajpur districts of Chhattisgarh. Moderately instability was found in production and yield for selected districts of Chhattisgarh, while high and low instability was found in production and yield for the Kanker and Surajpur districts of Chhattisgarh respectively. Negative linear growth rate and compound growth rate found in the area and production of the selected district, while Positive linear growth rate and compound growth rate found in yield of the selected district of Chhattisgarh except Balrampur district. The CGR of yield under linseed was found to be highest in the Sarguja district followed by Rajnandgaon, Surajpur, and Kanker districts during the overall period, which in turn has to depend on the weather, climatic changes soil structure, and productivity level of linseed crop was erratic.
The outcome of the result suggests that researchers and policy makers require to pay more attention to developing location-specific cultural practices to increase and sustain linseed production and yield in the state. Policies and programs should incentivize an increase in the area under cultivation to include non-traditional locations resulting in an increase in the overall linseed production.

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