Original Research Article

A Comparative Growth TrendStudy of Tomato in Jaipur and Sirohi District of Rajasthan

Abstract

Tomato (*Licopersicon esculentum*) is an important crop that contributes economically and significantly to horticulture production. The study was conducted in Jaipur and Sirohi districts of Rajasthan to analyze the growth rate in area, production, and production during the 12 years from 2010-11 to 2021-22. For analyzing the trend in area production and productivity of tomatoes in Jaipur and Sirohi district, and Rajasthan state the following linear, semi-log, and exponential functions were tested. Based on high R^2 (Coefficient of determination) the best-fit function was used for the result discussion. Semi-log function was best function for the area, production and productivity of Rajasthan. The compound annual growth rate (CAGR) for area of Rajasthan was found 1.76 percent, with 0.46 R^2. The production and productivity show 9.91 and 8.15 percent growth rate. The semi-log function was also best fit the area and production of Tomato in Jaipur district with 4.58 and 15.94 percent annual growth respectively. The linear function was fitted for the productivity that shows 17.20 percent CAGR with 0.39 percent R^2. The area of tomato in Sirohi district shows highest fluctuation due to this an exponential function was shows poor fits for calculate the growth rate this function shows 0.01 percent compound annual growth rate. The exponential function was best fit for the production and productivity with 0.41 and 0.31 R^2 respectively. The exponential function show 11.24 percent growth rate, which was significant at 5 percent level. The productivity show 12.25 percent compound annual growth rate with 10 percent level of significance. Thus the productivity shows highest compound annual growth rate followed by Production and area in Rajasthan state as well as Jaipur and Sirohi district of Rajasthan.

Key Words: - Tomato, Semi-log, CAGR, Area, Production and Productivity

Introduction

Tomato an economically important crop contributes significantly to horticulture production(Ghalawat*et al.* 2024).More than 40 kinds of vegetables from different groups are grown in India. Tomato, onion, brinjal, cabbage, cauliflower, okra, and peas are among the most important vegetables grown in India (Tegar*et al.* 2016).Tomatoes, onions, and potatoes, popularly known as the TOP vegetables, are the three largest cultivated, produced and consumed vegetables in India. Vegetables are excellent source of vitamins, particularly niacin, thiamin, riboflavin and vitamins A and C. They also supply minerals such as iron and calcium besides

proteins and carbohydrates (APEDA-2022,Shreyana*et al.* 2022,and Singh*et al.* 2023). For tomatoes, a well-known Indian saying is "No tomato, no cooking" but 99% of the tomatoes are currently consumed fresh as it is currently estimated that only about 150,000 tonnes of tomatoes are processed annually (Laxkar*et al.* 2022) In 2021-22, approximately 20300.19 tons of tomatoes were produced in 840 thousand hectares in the country making up almost 9.63 percent of the total vegetableproduction (Ghalawat*et al.* 2024).India has 2nd rank in botharea and production of tomatoes worldwide after China (Harisha *et al.*, 2019 & Gupta *et al.*, 2021). Despite its high production in India, the average productivity level remains low as compared to other tomato-producing countries (Ghalawat*et al.* 2024).Tomato is growing year-round as per the weathersuitability in different country locations. It has the advantage of both domestic consumption and international demand (Anamika *et al*., 2023).

In recent decades, India has witnessed considerable growth in the production and productivity of tomatoes. This growing trend has been influenced by various factors such as technological advancements, improved farming practices, changing market dynamics, climate change, government policies, and increasing demand globally (Ghalawat*et al.* 2024). During the year 2022-23, total vegetable output in Rajasthan was 2334884 MT in 192712 hectare area. Rajasthan has 20622 hectares area under tomato cultivation which contributes 10.70 percent of total vegetable cultivation. The total tomato output in Rajasthan was 255992 MT which contributes 10.96 percent of total vegetable output. During the year 2022-23, Jaipur stands on first position in tomato-producing districts in Rajasthan followed by Sirohi and Sikar. Jaipur district has a 13870-hectare area under tomato cultivation with 185477 MT production, which contributes 67.26 percent of the total tomato cultivated area and 72.45 percent total tomato production of Rajasthan respectively. With the 27335 MT production Sirohi district is the second-largest in tomato production and first largest in productivity of tomato in Rajasthan. Sirohi has 1287 hectare area under tomato cultivation, which contributes 6.24 percent of the total tomato cultivated area under Rajasthan and it contributes 10.67 percent of the total tomato production of Rajasthan (Department of Horticulture, Government of Rajasthan 2024).

Methodology

The study was conducted in the Jaipur and Sirohi districts of Rajasthan to analyze the growth rate in area, production, and production during the 12 years from 2010-11 to 2021-22.The research used statistical tools and quantitative analyses to extract insights from time series secondary data acquired from Rajasthan's horticulture department. For analyzing the trend in area production and productivity of tomatoes in Jaipur and Sirohi district, and Rajasthan state the following linear, semi-log, and exponential functions were tested. Based on high R^2 (Coefficient of determination) the best-fit function was used for the result discussion.

Linear function

$$Y= \alpha+ \beta t$$

Where,

Y = Area/production/productivity of tomato

α = Constant

β=Coefficient factor

t= Year factor

The annual linear growth rate by linear function was computed as follows

$$r = \frac{\beta 1}{\bar{y}} X\ 100$$

Semi log function

Log Y = α+ βt

Where,

Y = Area/production/productivity of tomato

α= Constant

β= Regression coefficient

t= time in the year

To obtain the annual semi-log growth rate, it was computed as follows as

$r = (\beta_1 * 100)$

Exponential function

$Y= \alpha\ \beta^t$

Taking both side logs for linear transformation of this functional model

Log Y= log α+ t log β

$Y^*= \alpha^*+ \beta^*$

Where,

Y^*= log Y

α^*= log α

β^*= log β

Where,

Y= Area/production/productivity of tomato

α= Constant

β= Regression coefficient

t= time in the year

The annual Exponential growth rate was then computed as $r = (e^{\beta 1}-1) \times 100$

e = Euler's exponential constant (=2.71828) (Sawant, 1983)

Result

Growth rate in area, production, and productivity of tomato in Rajasthan State.

As mentioned in the methodology, to calculate the growth rate in area, production, and productivity, all the growth given functions were tested as given in Table 1. Based on the function section criteria the semi-log function best fits at 1 percent level of significance for the area of Rajasthan with the highest 0.46 percent coefficient of determination (R^2) and minimum Root Mean Square Error (0.0722). By using this function the growth rate of the area of Rajasthan shows 1.76 percent compound annual growth during the 12 years from 2010-11 to 2021-22. By using this semi-log function, the predicted area of Rajasthan for the year 2023-24 was obtained at 20292.37 hectares and it was 20622 hectares for the same year on actual. For the growth rate in the production and productivity of Rajasthan, the semi-log function was the best fit at 1 percent level of significance, which shows 0.68 and 0.60 percent R^2. By this function, production shows a 9.91 compound annual growth rate and productivity shows an 8.15 percent compound annual growth rate in the study period. The RMSE for the production and productivity was 0.2533 and 0.2487 respectively. The predicted value for the production of tomatoes for the year 2022-23 was 182956 MT and it was 255992 MT in actual. The predicted value for the productivity of tomatoes for the year 2023-24 was 9043.49 quintal and it was 12413.53 MT in actual. Shreyana*et al.* 2022 studied for the period 2000-01 to 2009-10 which show negative growth rate in area, production and productivity by 0.13, 1.01 and 0.87 respectively.

Table:-1Growth rate in area, production, and productivity of tomato in Rajasthan State (2010-11 to 2021-22)

Response variable	Growth Function	Coefficients		R^2	RMSE	F Value	Growth rate (% per annum)
		β_0	β_1				
Area	Linear	16241.67	320.57	0.45	1324.91	8.37	1.74*
	Semi log	**9.697**	**0.017**	**0.46**	**0.0722**	**8.56**	**1.76***
	Exponential	9.68	0.077	0.39	0.0766	6.46	2.86*
Production	Linear	24569.20	12789.21	0.57	41275.61	13.72	11.87*
	Semi log	**10.83**	**0.099**	**0.68**	**0.2533**	**21.92**	**9.91***
	Exponential	10.83	0.392	0.47	0.3284	8.99	14.45*
Productivity	Linear	2072.10	566.35	0.54	1965.71	11.87	9.84*
	Semi log	**8.0503**	**0.0815**	**0.60**	**0.2487**	**15.36**	**8.15***
	Exponential	8.055	0.315	0.39	0.3074	6.60	11.59*

Note: - * indicates 1 percent level of significance.

Laxkar*et al.* 2022 studied on growth rate in area production and productivity for the Madhya Pradesh (MP) and Andhra Pradesh (AP) for the 10 year period form 2010-11 to 2020-21. The finding was that the MP's area, production and productivity show positive growth rate with 7.85, 12.72 and 4.51 percent CGR respectively, while AP's area and production shows negative growth rate by 19.23 and 9.22 percent CGR and productivity show positive growth rate by 12.40 percent CGR.

The growth rate in area, production, and productivity of tomatoes in the Jaipur District of Rajasthan

Table 2 shows the all three tested function for calculate the growth rate in area, production and productivity in Jaipur district of Rajasthan. The semi-log function was best fits for the area and production of Jaipur district with highest 0.86 and 0.46 R2 and lowest, 0.067 and 0.646 Root Mean Square Error respectively with 1 percent significant level. The semi-log function shows 4.58 and 15.94 percent compound annual growth rate in area and production in Jaipur district during the 12 year period. For calculate the productivity of Jaipur district, linear function was best fits at 5 percent level of significance.

Table 2. Growth rate in area, production, and productivity of tomato in Jaipur district of Rajasthan (2010-11 to 2021-22)

Response variable	**Growth Function**	**Coefficients**		**R^2**	**RMSE**	**F Value**	**Growth rate (% per annum)**
		β_0	**β_1**				
Area	Linear	6639.36	454.09	0.82	785.14	47.83	4.73*
	Semi log	**8.855**	**0.045**	**0.86**	**0.067**	**65.34**	**4.58***
	Exponential	8.82	0.196	0.69	0.1021	23.28	7.23*
Production	Linear	21874.70	10136.05	0.44	42788.25	8.0246	23.03*
	Semi log	**9.2177**	**0.1594**	**0.46**	**0.6469**	**8.688**	**15.94***
	Exponential	9.34	0.543	0.23	0.772	3.117	20.00^{NS}
Productivity	**Linear**	**-474.44**	**690.23**	**0.39**	**3222.96**	**6.55**	**17.20****
	Semi log	7.270	0.113	0.33	0.6057	5.02	11.35**
	Exponential	7.429	0.347	0.13	0.6896	1.594	12.77^{NS}

Note: - * indicates 1 percent level of significance, ** 5 percent level of Significance and NS indicates Non-Significant.

The linear function shows 0.39 percent R2 and that shows 17.20 percent compound annual growth rate in productivity of Jaipur district. By using the semi-log function, the predicted value of area for the year 2022-23 was 12581.72 hectare and it is in actual 13870.00 hectare but due to low R2 for the production and productivity, the predicted value shows more variation form actual value. The production of Rajasthan and Jaipur district tomato suddenly got increase during the year 2019-20 to 2020-21, due to an increase in the area in the same period.

The growth rate in area, production, and productivity of tomatoes in the Sirohi District of Rajasthan.

Table 3 shows about the all three tested function for calculate the growth rate in area, production, and productivity in the Sirohi district of Rajasthan. It was found that the area of tomatoes in the Sirohi district shows the highest fluctuation due to this an exponential function shows poor fits for calculating the growth rate this function shows a 0.01 percent compound annual growth rate. The exponential function was best fit for the production and productivity with 0.41 and 0.31 R2 respectively. The exponential function showsan 11.24 percent growth rate, which was significant at the 5 percent level.

Table 3. Growth rate in area, production, and productivity of tomato in the Sirohi district of Rajasthan (2010-11 to 2021-22)

Response variable	Growth Function	Coefficients		R^2	RMSE	F Value	Growth rate (% per annum)
		β_0	β_1				
Area	Linear	1287.89	-4.95	0.003	321.84	0.033	-0.39 ^{NS}
	Semi log	7.1256	-0.002	0.001	0.241	0.014	-0.23 ^{NS}
	Exponential	**7.1557**	**-0.0274**	**0.008**	**0.240**	**0.081**	**0.01** ^{NS}
Production	Linear	14642.98	1088.45	0.34	5618.68	5.366	5.01**
	Semi log	9.5683	0.05606	0.31	0.3134	4.574	5.60***
	Exponential	**9.4235**	**0.305**	**0.41**	**0.2906**	**6.955**	**11.24****
Productivity	Linear	12727.98	857.104	0.18	6749.103	2.306	4.68 ^{NS}
	Semi log	9.350	0.0548	0.22	0.4158	2.826	5.84^{NS}
	Exponential	**9.175**	**0.333**	**0.31**	**0.3898**	**4.589**	**12.25*****

Note: - ** and *** indicates 5 and 10 percent level of Significance and NS indicates Non-Significant.

The productivity show 12.25 percent compound annual growth rate with 10 percent level of significance. The productivity of tomato show more fluctuation in the Sirohi district because fruit set in tomato influenced by the fluctuations in the temperature and humidity. During the year August 2015 the maximum temperature was 35°c with 98 percent humidity, in the same minimum temperature and humidity was 25°c and 46 percent respectively. In the August 2016 the maximum temperature and humidity was 36°c and 100 percent and the minimum temperature of this period was 24°c with 49 percent humidity.

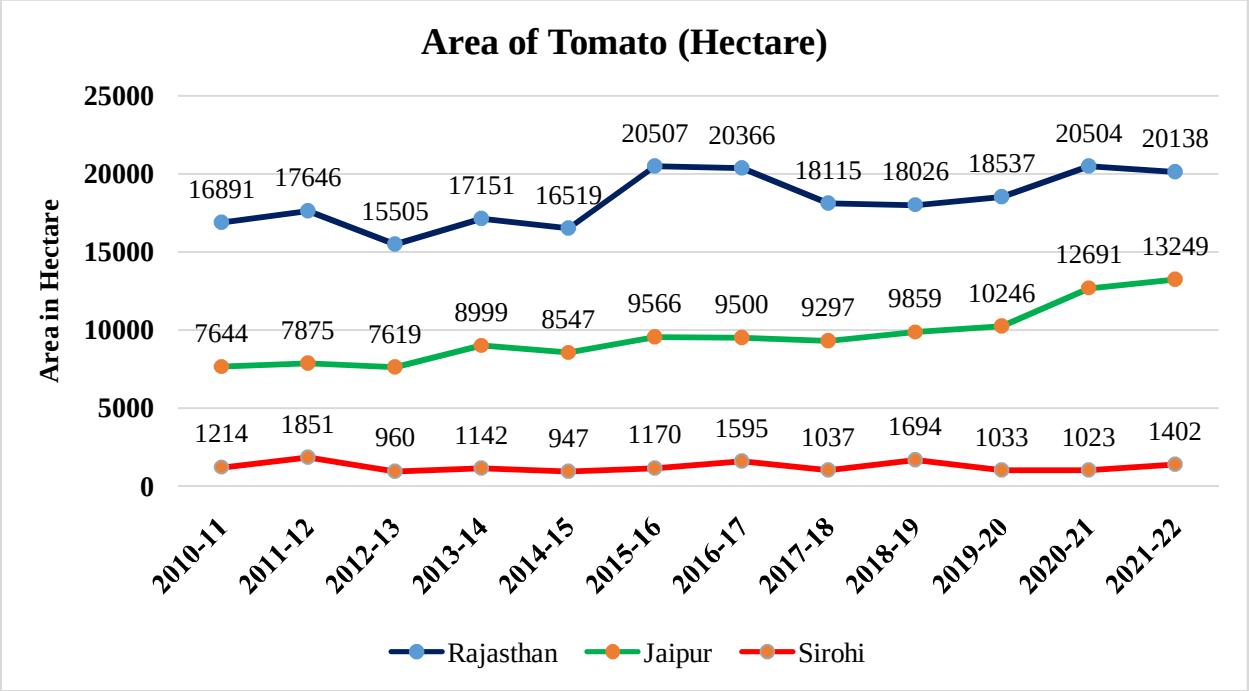

Fig.1Area of Tomato in Rajasthan state with Jaipur and Sirohi district.

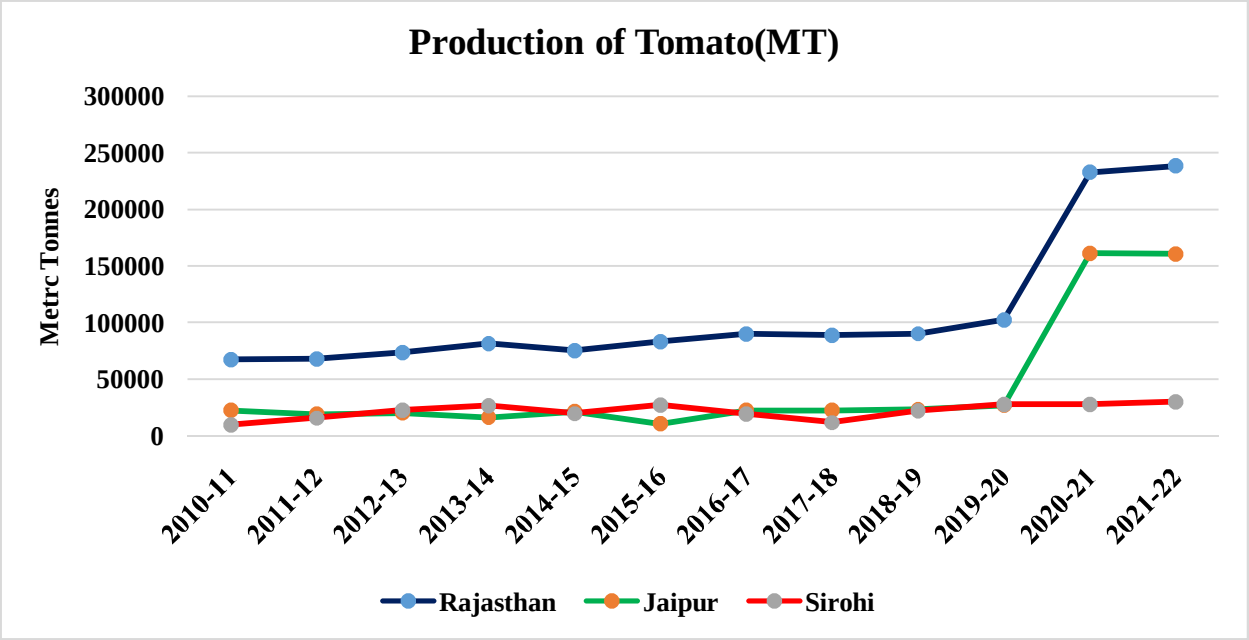

Fig.2 Production of Tomato in Rajasthan state with Jaipur and Sirohi district.

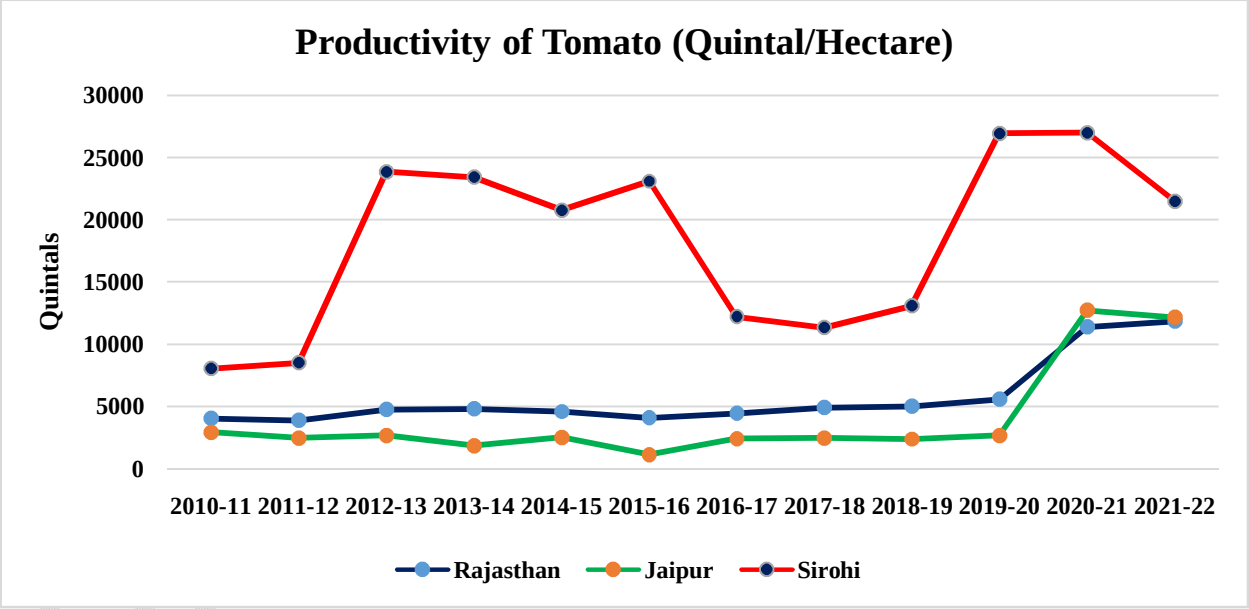

Fig.3 Productivity of Tomato in Rajasthan state with Jaipur and Sirohi district.

Discussion and Conclusion

The area, production and productivity of Rajasthan shows significantly positive growth rate during the 12 year study period from 2010-11 to 2021-22. The compound annual growth rate for area was found 1.76 percent, that increase from 16891 to 20138 hectare in the study period. The production and productivity shows 9.91 and 8.15 percent compound annual growth rate that was increased from 67466 MT to 238393 MT in production and productivity was increased from 3994 to 11838 quintal per hectare. Jaipur district also show positive growth trend in area,

production and productivity of tomato. The area show 4.58 percent compound annual growth rate that was increased from 7644 to 13249 hectare. The production was increased from 22437 MT to 160586 MT, which shows 15.94 percent compound annual growth rate of tomato in Jaipur district. The productivity was increased from 2935 to 12121 quintal per hectare which show 17.20 percent compound annual growth rate at 5 significant level. The area of Sirohi district was increased from 1214 to 1402 hectare, which show non-significant compound annual growth in area of tomato in Sirohi district. The production shows 11.24 percent compound annual growth in tomato production at 5 percent significant level. It was increased from 9741 to 30110 MT per hectare. The productivity was increased from 8024 to 21476 quintal per hectare with 12.25 percent compound annual growth at 10 percent significant level. Thus the productivity shows highest compound annual growth rate followed by Production and area in Rajasthan state as well as Jaipur and Sirohi district of Rajasthan.

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