IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 7, June 2026
Impact Factor: 8.2

A Statistical Study on Grapes Production and Export Trends in Sangli District

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Abstract: *In this paper we study the statistical analysis of grapes production and export trends in Sangli district. Grapes are one of the major agricultural commodities contributing to the economy of this region. The study focuses on production levels, cost structure, sugar content, and export patterns over the past three years. Various statistical tools such as mean, correlation, regression analysis, chi-square test, and paired t-test are used to analyze the data. The results show that grape production was highest in 2024 and there exists a strong relationship between production and input costs. It is also observed that higher sugar level grapes are preferred for export quality. Finally, the study highlights major challenges faced by farmers and provides useful insights for improving grape production and export performance.*

Keywords: Grapes Production, Export Trends, Statistical Analysis, Correlation, Regression, Sugar Level.

I. INTRODUCTION

India is one of the leading producers and exporters of grapes in the world, and grape cultivation plays a vital role in the agricultural economy of regions like Maharashtra. Grapes are a high-value fruit crop and are mainly cultivated for both domestic consumption and international export. Farmers invest significant resources in land, labor, fertilizers, and infrastructure to maintain vineyards and improve production quality.This project, titled "A Statistical Study on Grapes Production and Export Trends", aims to analyze various aspects of grape farming, particularly focusing on production statistics, export trends, costs involved, and profit margins. The study is based on primary data collected through a structured questionnaire administered to grape farmers.The questionnaire covers important aspects such as the type of soil, variety of grapes cultivated, annual production, labor and fertilizer costs, average selling prices over the last three years, sugar content of the grapes, and challenges faced in production and export. The responses are statistically analyzed using tools such as measures of central tendency, correlation, and trend analysis to identify key patterns and insights.The goal of this project is to not only understand the production and economic aspects of grape farming but also to identify strategies that can help improve grape export and support farmers in achieving better profitability

II. DATA COLLECTION AND METHODOLOGY

This study is primarily based on primary data collected directly from grape-exporting farmers. The data was gathered through a structured questionnaire specifically designed to capture information on grape production, costs, export details, and related challenges.A total of 123 farmers were surveyed from the villages of Belanki and Vikasnagar, located in the grape-producing belt. These farmers are actively involved in grape cultivation and export to various international markets such as Bangladesh,Dubai,Bangal and other countries.

Out of approximately 178 grape-exporting farmers in the region, the selected sample represents a significant portion, ensuring that the findings of this study are both relevant and reliable.

The collected data was then analyzed using statistical tools to derive insights regarding production trends, pricing patterns, profitability, and challenges in grape export.

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Sample Size Determination:The data collection followed the Simple Random Sampling (SRS) method, ensuring each grape- exporting farmer from the selected villages had an equal chance of participation.
The study was conducted in Belanki and Vikasnagar villages, which have a total of N = 178
grape-exporting farmers.

Sample Size Calculation using Slovin's Formula: Slovin's Formula:

$$n = \frac{N}{1+(N*e^2)}$$

Where:
n = Sample size , N= Population size = 178
e= Margin of error (commonly 0.05 for 5%)

$$n \equiv \frac{178}{(1+(180*0.05*0.05)}$$

n=123

Hence, according to Slovin's formula with a 5% margin of error, a sample of 123 farmers is sufficient. In this study, data from 123 farmers was collected, which is very close to the required sample size and statistically acceptable.

III. STATISTICAL TOOLS

1) Mean

An mean sum of all the numbers divided by the total number of values in the
set. The term mean is finding of the average of a sample data. The formula for mean is,

$$\text{Mean} = \frac{\sum xi}{n}$$

2) Standard Deviation: To measure variability in production, pricing, and costs among different farmers.

3) Correlation

Correlation is useful for describing simple relationship among data. We decide the type of correlation by using correlation coefficient (r). Range of correlation coefficient (r) is -1 to +1. Here correlation coefficient is find by using following formula;

$$r = \frac{\sum(xi-\dot{x})(yi-\bar{Y})}{\sqrt{\sum(xi-\dot{x})^2)(\sum(yi-Y)^2)}}$$

Decision Criteria for Correlation,

If r = 0 then there is no correlation between two variables.
If r < 0, then there is negative correlation between two variables.
If r > 0, then there is positive correlation between two variables.

4) Paired t-test

A paired t-test is a statistical test used to compare two related sets of data, usually before and after a condition or across two time points for the same subjects.

H□: There is no significant difference in grape production between 2023 and 2024.i.e.

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H1:μd=0 V/sH□: There is a significant difference in grape production between 2023 and 2024.(μd≠0) where μd is the

$$t = \frac{me(d)}{s.d(d)/\sqrt{n}}$$

mean of the differences between 2024 and 2023 production for each farmer.
Where: Mean(d) = Mean of the differences (2024 – 2023 production for each farmer) S.d.(d)= Standard deviation of the differences , n= Number of paired observations

5) CHI – SQUARE TEST FOR INDEPENDENCE:
H□: The two attributes are independent.V/S
H□: The two attributes are not independent.
Test Statistic:

The test statistic for the Chi-Square Test is given by:

$$cal\ \chi 2 = \sum\sum \frac{(Oij-eij)^2}{eij} \qquad i=1,2,\ldots\ldots,r \text{ and } j=1,2,\ldots\ldots s$$

Where, Oij = Observed frequency in the ith row and jth column
eij = Expected frequency for that cell
Expected frequency is calculated using:

$$eij = \frac{Rowtotali * columntotalj}{grandtotal}$$

Compare the calculated χ2 value with the critical value from the Chi-square distribution table at a chosen significance level α (commonly 0.05).

If $cal\ \chi 2 > tab\ \chi 2$ then reject H0 otherwise accept it.

Statistical Analysis
•Average production over years 2024,2023,2025

Average of production in 2024	Average of production in 2023	Average of production in 2025
1433536.211	1345492.911	1322913.691

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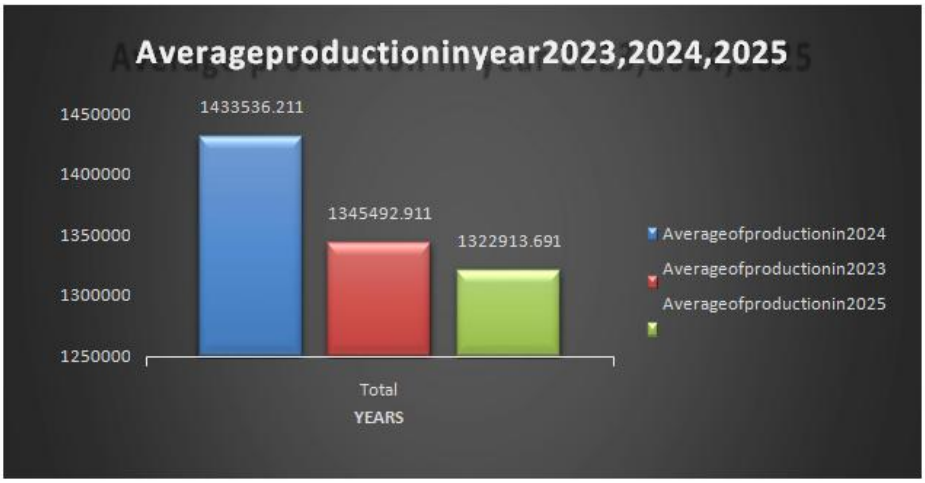
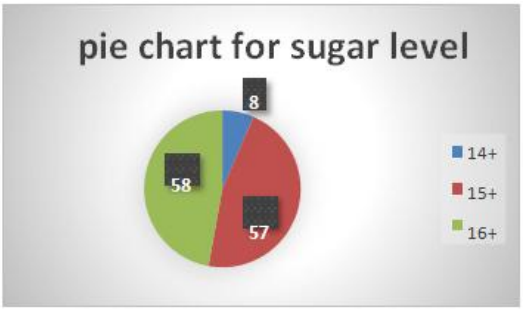


Interpretation: The highest average grape production was in 2024 at around 14.3 lakh. Production slightly dropped in 2025 to 13.2 lakh and was 13.4 lakh in 2023. This suggests 2024 was a better year for grape farming.

- **Pie chart for sugar level**

Sugar level	Count of sugar level
14+	8
15+	57
16+	58
Grand Total	**123**



Interpretation: The pie chart indicates that the majority of farmers have grape sugar levels in the 16+ and 15+ range. Specifically, 16+ accounts for the highest number (58 farmers), closely followed by 15+ (57 farmers). Only a small portion, 8 farmers, report a sugar level of 14+. This suggests that most grape production aims for higher sugar content, which may be preferred for quality or market demand.

- **Average cost by land area**

Row Labels	Average of fertilizer cost	Average of labour cost	Average of other expenses
1	151188.9063	72837.65625	26864.78125
1.5	245053.6563	112993.6875	53335.84375
2	290496.4483	130229.9655	69619.72414
3.5	426265.8	219601.7	121531.1333
Grand Total	**275545.7967**	**132612.3821**	**66921.34959**

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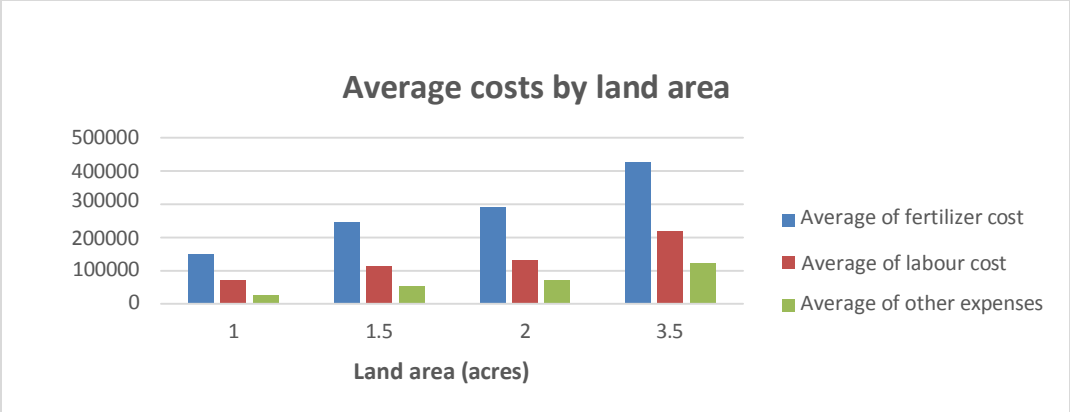
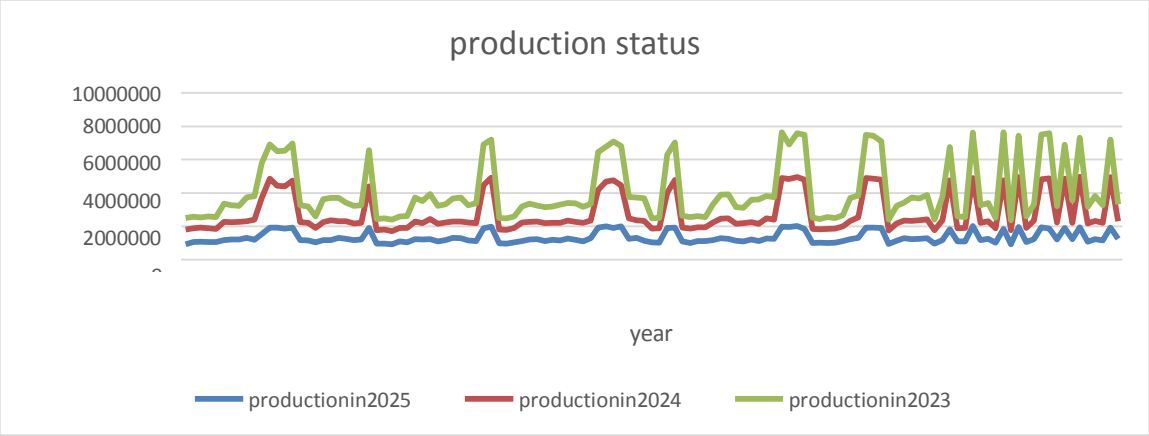


Interpretation: As land area increases, average fertilizer, labour, and other expenses also rise. 1 – acre farms have the lowest cost, while 3.5 – acre farms have the highest. From 1 to 1.5 acres, there's sharp increase in all costs, especially other expenses. Farming on 2 acres shows further cost growth compared to smaller plots.

- **production status for years 2023,2024,2025 :**



Interpretation: Production shows a cyclical pattern across years 2023,2024,2035. Overall production has generally increased year-over-year. Recent data indicates a strong upward trend in 2025 production . This suggests growth and potentially predictable fluctuations in output.

DOI: 10.48175/IJARSCT-36862

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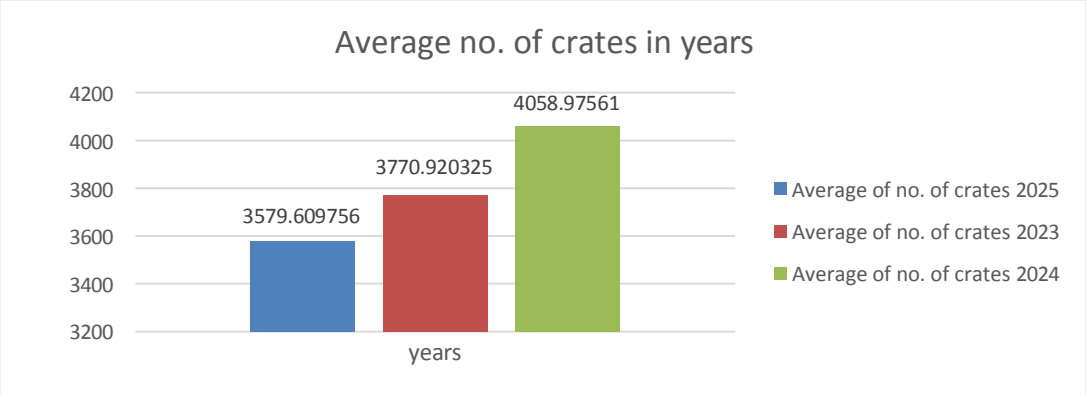
- **Average number of crates :**



Interpretation: The average number of grape crates produced over the three years shows a fluctuating trend. In 2023, the average production was 3770 crates, which increased to 4058 crates in 2024, indicating positive growth. This rise could be attributed to favorable weather conditions, better farming practices, or increased demand in the market. However, in 2025, the average dropped to 3579 crates, suggesting a decline in production. This decrease might be due to adverse climatic conditions, pest attacks, or market- related challenges

- **Correlation Analysis :**

	labour cost	fertilizer cost	other expenses	amount of trees	Production in 2025
labour cost	1				
fertilizer cost	0.978247361	1			
other expenses	0.985300937	0.989465971	1		
amount of trees	0.972719289	0.96652085	0.981432565	1	
production in 2025	0.953706827	0.928860849	0.950696328	0.954273879	1

Interpretation: The correlation matrix reveals strong positive relationships among all the variables involved in grape production. Labour cost, fertilizer cost, and other expenses are highly correlated with each other, with coefficients above 0.97, indicating that when farmers spend more on one input, they are likely to spend more on others as well. The amount of trees also shows a strong correlation with all cost- related variables, meaning that as the number of trees increases, so do the associated labour, fertilizer, and other expenses. This is expected, as managing a larger number of trees naturally requires more resources.

Production in 2025 is highly correlated with all the variables, particularly with the amount of trees (correlation = 0.9543), followed closely by labour and other expenses. This indicates that higher production levels are associated with both greater input costs and a larger number of trees. Overall, all variables show a positive relationship with production, suggesting that increased investment and more trees generally lead to better yields.

- **Paired t test:**

H□: There is no significant difference in grape production between 2023 and 2024. V/s
H□: There is a significant difference in grape production between 2023 and 2024.

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$$t = \frac{me(d)}{s.d(d)/\sqrt{n}}$$

$$t = \frac{88043.3}{288075.3/sq(123)} = 3.3895$$

tab t = tab t(0.05,122) = 1.9796

Interpretation : tab t < cal |t| then we reject null hypothesis and conclude that there significant difference between production in 2023 and 2024

- **Chi square test :** here we want to test the hypothesis,

H□: There is no association between grape variety and soil type.
i.e.Grape variety and soil type are independent.) V/S

H□: There is an association between grape variety and soil type.
(Grape variety and soil type are not independent.)

Observed table is :

Soil type/grape variety	super sonaka	thomson	Blackgrapes	total
Black	33	18	10	61
Rocky ground	24	26	12	62
Total	57	44	22	123

Expected frequencies are :

Soil type/grape variety	super sonaka	thomson	Black grapes	total
Black	28.26829	21.82114	10.91057	61
rockyground	28.73171	22.17886	11.08943	62
Total	57	44	22	123

Observation table:

Ei	Ei	oi	(oi-ei)^2/ei
61*57/123	28.26829	33	0.79202
61*44/123	21.82114	18	0.669126
61*22/123	10.91057	10	0.075994
62*57/123	28.73171	24	0.779246
44*62/123	22.17886	26	0.658334
22*62/123	11.08943	12	0.074768
		total	3.049488

Test Statistic :

The test statistic for the Chi-Square Test is given by:

$$cal\ \chi 2 = \sum\sum \frac{(Oij-eij)\text{^}2}{eij} \qquad i=1,2,\ldots\ldots\ldots,r \text{ and } j=1,2,\ldots\ldots\ldots s$$

$$= 3.0494$$

$$\text{Tab } \chi 2 = \chi 2_{\ (0.05,2)} = 5.991465$$

Interpretation: Therefore $cal\ \chi 2$ <Tab χ2 . Hence we fail to reject null hypothesis and conclude that grape variety and soil type are independent.

- **Test for proportion:**

p□ = proportion of farmers with sugar level 15+ , **p**□ = proportion of farmers with sugar level 16+

here we want to test the hypothesis,

H□ **:** p□ = p□ V/S H□ : p□ ≠ p2

The test statistic is,

$$z = \frac{p1 - p2}{\sqrt{p(1-p)(\frac{1}{n1} + \frac{1}{n2})}}$$

$$p = \frac{n1*p1 + n2*p2}{n1+n2}$$

calculation:

x1=57,n1=123,x2=58,n2=123

$p1=\frac{x1}{n1}$ =57/123= 0.4634

$p2=\frac{x2}{n2}$ = 58/``123 = 0.4715

p=(57+58)/(123+123) =0.4675

$$z= \frac{0.4634-0.4634}{\sqrt{0.4675*(1-0.4675)(\frac{1}{123}+\frac{1}{123})}} = -0.1274$$

tab z = 1.96

cal |z| < tab z , we fail to reject null hypothesis at 5 % l.o.s.

Conclusion : There is no significant differences in the proportions between the two groups.

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- Regression:

	Coefficients
Intercept	758839.4
labour cost	4.214834
fertilizer cost	-2.32043
other expenses	9.631007

Production =758839.44+4.21×(Labour Cost)−2.32×(Fertilizer Cost)+9.63×(other Expenses)

Interpretation : The regression equation shows how different costs affect grape production in 2025. According to the model, when labour cost increases by □1, the production increases by about 4.21 units. On the other hand, if fertilizer cost goes up by □1, production decreases by around 2.32 units, which may suggest that excessive use of fertilizers could be harmful or inefficient. For other expenses, a □1 increase leads to an increase of about 9.63 units in production, indicating that these expenses (possibly on quality improvements or better farming practices) positively contribute to yield.

The intercept value of 758839.44 represents the base level of production when all costs are zero, though this is more of a mathematical starting point. Overall, the equation helps us understand that labour and other general expenses have a positive effect on grape production, while fertilizer cost might have a negative impact if not used properly.

IV. CONCLUSION

- The study identified 2024 as the year with the highest average grape production, reaching approximately 14.3 lakh, indicating favorable conditions or effective farming practices during that period.
- A key observation was the focus on higher sugar content in grape production, which aligns with market demand and quality standards. A comparison of the proportion of farmers achieving 15+ and 16+ sugar levels showed a statistically significant difference highlighting variation in production quality.
- Cost analysis based on landholding size revealed that average fertilizer, labor, and miscellaneous expenses increase with larger land areas. This trend illustrates the scale effect on input requirements.
- Data from 2025 shows a notable upward trend in grape production, suggesting growth and pointing to predictable fluctuations in output, potentially useful for future forecasting.
- Production=758839.44+4.21×(Labour Cost)−2.32×(Fertilizer Cost)+9.63×(Other Expense s)
- A Chi-square test confirmed that grape variety and soil type are independent, indicating no significant association between these two variables.
- Correlation analysis demonstrated that production in 2025 is highly correlated with all input variables, most significantly with the number of grape trees (r = 0.9543), followed by labor and other expenses. This suggests that higher production levels are strongly associated with greater input investment and larger plantation sizes.
- The average number of grape crates produced over the three years shows a fluctuating trend. In 2023, the average production was 3770 crates, which increased to 4058 crates in 2024, indicating positive growth. This rise could be attributed to favorable weather conditions, better farming practices, or increased demand in the market. However, in 2025, the average dropped to 3578 crates, suggesting a decline in production. This decrease might be due to adverse climatic conditions, pest attacks, or market-related challenges
- The word cloud highlights that pest attacks, labor shortage, high input costs, and transport issues are the most common challenges faced by grape farmers. These issues significantly affect production, quality, and profitability in grape cultivation and export.

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