Andhra Pradesh J Agril. Sci : 12(3): 237-245, 2026

AN ANALYTICAL STUDY ON FARMERS' SATISFACTION AND DETERMINANTS INFLUENCING ADOPTION OF TISSUE CULTURE BANANA (TCB) CULTIVATION IN ANNAMAYA AND NANDYALA DISTRICTS OF ANDHRA PRADESH

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Date of Receipt: 13-05-2026 Date of Acceptance: 30-05-2026

ABSTRACT

This study examined the satisfaction levels and adoption factors of tissue culture banana (TCB) cultivation among farmers in Annamaya and Nandyala districts of Andhra Pradesh. TCB is favored for its disease-free planting material, uniform growth and higher yield potential. Most farmers expressed high satisfaction with yield performance and fruit quality, though concerns remained regarding pest resistance and limited access to subsidies. Satisfaction was measured using a 5-point Likert scale and Principal Component Analysis (PCA) was applied to 20 key statements. The analysis revealed seven major components influencing adoption, accounting for (64.72%) of the total variance. Key factors included uniform harvest, disease resistance, economic viability and institutional facilitation. The findings indicate that while the technical benefits of TCB are strong motivators, adoption decisions are also significantly shaped by structural aspects such as training, market linkages and subsidy delivery. Farmers are more likely to continue with TCB when both agronomic and institutional supports are present. Therefore, a balanced approach combining technology with robust support systems is essential for the sustainable success of TCB cultivation.

KEYWORDS: Tissue culture banana, farmers satisfaction, adoption factors, likert scale, principal component analysis.

INTRODUCTION

Banana (*Musa* spp.) is one of the most important fruit crops in India, contributing significantly to food security, nutrition and rural livelihoods. Andhra Pradesh is among the leading banana-growing states, where the crop serves as a major source of income for farming households. Traditionally, banana cultivation has relied on sucker propagation; however, this method often results in non-uniform growth, disease transmission and lower productivity.

Tissue culture banana (TCB) technology has emerged as an effective alternative by providing disease-free, genetically uniform and high-yielding planting material. Studies by (Anyango *et al.,* 2010) and (Kabunga *et al.,* 2012) reported that tissue culture banana cultivation improves productivity, fruit quality and farm income. Similarly, (Flarian *et al.,* 2018) highlighted the role of tissue culture technology in enhancing banana production and profitability. Due to these advantages, the adoption of tissue culture banana has increased in several banana growing regions.

Despite its benefits, adoption of tissue culture banana is influenced by various socio-economic, institutional and technical factors. (Thuo *et al.,* 2017) and (Omari *et al.,* 2023) reported that education, extension support, market access and access to credit significantly affect adoption decisions. (Wanyama *et al.,* 2016) emphasized the importance of quality planting material and institutional support, while (Mulugo *et al.,* 2019) found that social influence and farmer innovativeness positively influence technology adoption. However, constraints such as high plantlet costs, inadequate technical knowledge and limited support services continue to hinder wider adoption (Shukla *et al.,* 2018; Bairwa *et al.,* 2015).

Although tissue culture banana cultivation is gaining popularity in Andhra Pradesh, limited information is available regarding farmers' satisfaction and the factors influencing its adoption in the Rayalaseema region. Therefore, the present study was undertaken in Annamaya and Nandyala districts of Andhra Pradesh to assess farmers' satisfaction with tissue culture banana cultivation and identify the key factors influencing its adoption.

MATERIAL AND METHODS

The study was conducted in Annamaya and Nandyal districts of Andhra Pradesh, targeting 120 purposively

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selected farmers with experience in tissue culture banana (TCB) cultivation.

Data were collected through a structured interview schedule covering satisfaction levels and factors influencing TCB adoption. Satisfaction was measured using a 5-point Likert scale across seven key areas and Chi-square test was conducted to examine the association between the source of plantlets and satisfaction with the availability of plantlets

To identify adoption factors, Principal Component Analysis (PCA) was performed on 20 statements. KMO and Bartlett's tests ensured data suitability and components with eigenvalues over 1 were retained using Varimax rotation.

Chi-Square Test

This non-parametric test helps to determine whether a statistically significant relationship exists between two variables.

$$\chi^2 = \sum \frac{(O-E)^2}{E} \sim \chi^2_{(r-1)(c-1)df}$$

Where:

χ^2 = Chi-Square statistic

O = Observed frequency (from your actual data)

E = Expected frequency

r = number of rows

c = number of columns

df = degrees of freedom

Factor Analysis

To identify the underlying various factors that impact farmers decisions to cultivate tissue culture banana, exploratory factor analysis was conducted. This technique grouped related variables into a smaller set of independent factors using Principal Component Analysis (PCA) with Varimax rotation. Only factors with eigenvalues greater than 1 were retained. Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity were used to verify the adequacy of the sample for factor analysis.

Basic Factor Analysis Equation

Let

$x_1,x_2,\ldots,x_p$ = observed variables

$F_1,F_2,\ldots..,F_m$ = common factors (latent)

$u_1,u_2,\ldots\ldots,u_p$ = unique (error) factors

Then the Factor Model is:

$$x_i = \lambda_{i1}F_1 + \lambda_{i2}F_2 + \cdots\cdots + \lambda_{im}F_m + u_i$$

Where:

λ_{ij} = factor loading of variable x_i on factor F_j

u_i = unique variance for variable x_i

Definitions and Terms Used in the Factor Analysis

Factor

A factor is a linear combination of the original observed variables. It represents an underlying dimension that helps to summarize and explain the patterns of correlations among a set of variables.

Factor Loadings

Factor loadings indicate the correlation between each observed variable and the underlying factor. Higher loadings suggest a stronger association of the variable with the respective factor.

Eigenvalues

Eigenvalues reflect the amount of variance in the data explained by each factor. Only factors with eigenvalues greater than 1 are usually retained for further analysis, as they represent substantial underlying patterns.

Factor Rotation

Factor rotation is the process of adjusting the factor axes to achieve a simpler and more interpretable structure. In this study, Varimax rotation, an orthogonal method, was used to obtain uncorrelated and distinct factors.

Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy

KMO measures the adequacy of the sample size for factor analysis. It ranges from 0 to 1, with values above 0.6 generally considered acceptable for proceeding with factor extraction.

Table 1. Satisfaction level towards tissue culture banana plantlets

S. No.	Particulars	Mean Score	Mean (±) SD	Satisfaction Level
1.	TCB Satisfaction plantlet quality and Growth performance	3.85	3.85 (±) 0.97	Satisfied
2.	TCB Satisfaction Yield	4.44	4.44 (±) 0.51	Highly Satisfied
3.	TCB Satisfaction Resistant for pest, disease and wind velocity	2.29	2.29 (±) 0.89	Dissatisfied
4.	TCB Satisfaction Fruit quality	3.90	3.90 (±) 0.90	Satisfied
5.	TCB Satisfaction Service facility in door delivery of plantlets	3.51	3.51 (±) 1.18	Satisfied
6.	TCB Satisfaction Availability of Plantlets	3.81	3.81 (±) 0.86	Satisfied
7.	TCB Satisfaction Subsidy for TCB	1.69	1.69 (±) 0.48	Highly Dissatisfied

Table 2. Association between availability of plantlets vs source of purchase

S. No.	Source of Plantlets	Satisfaction level			Total	Chi-square statistic (χ^2)	p-value
		Not Satisfied	Neutral	Satisfied			
1.	Private	5 (4.17%)	27 (22.5%)	51 (42.5%)	83 (69.1%)	11.936	0.0178*
2.	Dealer	1 (0.83%)	10 (8.33%)	17 (14.17%)	28 (23.3%)		
3.	Ratoon	3 (2.5%)	0 (0%)	6 (5%)	9 (7.5%)		
	Total	9 (7.5%)	37 (30.8%)	74 (61.6%)	120 (100%)		

*Significance at 0.05 level of significance

Table 3. Kaiser-meyer-olkin and bartlett's test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0.761**
Bartlett's Test, of Sphericity	Approx. Chi-Square	678.342
	DF	190
	P-value	<0.001

Bartlett,s Teat of Sphericity

This test checks whether the correlation matrix is significantly different from an identity matrix, which would imply that the variables are related and suitable for factor analysis. A significance level (p-value) less than 0.05 indicates that factor analysis is appropriate.

Communality (Common Variance)

Communality refers to the proportion of each variable's variance that can be explained by the extracted factors.

Correlation Matrix

A correlation matrix shows the pairwise correlations between all the observed variables used in the analysis. It is the basis for identifying variables that can be grouped together under common factors.

Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is a multivariate statistical technique used for reducing the dimensionality of large datasets while preserving as much variability as possible.

Scree Plot

A scree plot visually represents the eigenvalues of each factor in descending order. It helps in determining the number of factors to retain by identifying the point where the curve flattens (the "elbow").

RESULTS AND DISCUSSION

Satisfaction Level of Farmers with Tissue Culture Banana

The respondents were asked to express their level of satisfaction on various aspects of tissue culture banana (TCB) plantlets using a 5-point Likert scale, Ranging from Highly Dissatisfied (1) to Highly Satisfied (5). The satisfaction scores were then averaged to determine the overall perception of farmers. The results were presented in Table 1. These findings are similar to the results of (Omari *et al.,* 2024)

The results of the satisfaction analysis revealed a generally positive perception of TCB technology among the respondents. The highest satisfaction was recorded for yield performance (Mean score = 4.44), followed by fruit quality (3.90), plantlet quality and Growth performance (3.85), availability of plantlets (3.81), Service facility in door delivery of plantlets (3.51), Resistant for pest, disease and wind velocity (2.29), Subsidy for TCB (1.69).

The chi-square test result showed in Table 2 indicated that p-value 0.0178 at 5 per cent level of significance suggest that satisfaction scores were significantly associated with variables such as availability of plantlets and source of plantlets, suggesting that external support mechanisms influence user experience.

Factor Analysis on Adoption Influencers

From Table 3 The KMO value of 0.761 confirmed the adequacy of the sample for PCA. Bartlett's Test of Sphericity was significant at 1 per cent level of significance, indicating that correlations among items were sufficient for dimensional reduction.

Rotated Component Matrix

The rotated component matrix displays the loading values for each variable related to the factors influencing farmers' decisions to grow tissue culture banana. Based on these factor loadings, the variables were grouped into seven distinct decision-driving categories, as illustrated in Table 4.

Grouping of Extracted Factors

The variables extracted from each benefit column were grouped according to their factor loadings in Table 5.

Benefits derived by farmers by growing Tissue culture Banana

From The extracted seven factors benefits that are driven by farmers are ranked and listed in Table 6.

A total of seven principal components were extracted, explaining 64.72 per cent of the total cumulative variance.

Uniform and Early Harvest, with a mean score of 4.01 was identified as a major perceived benefit, indicating that farmers highly value the consistency in crop maturity and the ability to plan harvests and market sales more efficiently.

Crop Protection and Year-round Production, with a mean score of 3.79 emerged as another key benefit, highlighting farmers' appreciation for stress tolerance, disease resistance, and the capability of the crop to produce across all seasons.

Table 4. Rotated component matrix

Rotated Component Matrix[a]							
	Component						
	1	2	3	4	5	6	7
Quality of the plantlets	0.559						
High yield	0.232						
Drought Tolerant	0.790						
Disease resistance	0.721						
Tissue culture plants will be of same age and same variety	0.674						
Resistant to wind velocity		0.785					
Due to the adoption of drip irrigation technology		0.604					
Subsidy for planting Tissue culture Banana		0.718					
Good value in exporting of G9 Banana fruit		0.696					
Attractive yellow colour for local marketing			0.402				
Good keeping quality / shelf life			0.611				
Best in ratoon cropping			0.481				
Low cost of irrigation			0.539				
Weight of the finger is higher than the other variety				0.737			
Good taste, most preferable by consumers				0.668			
Insect resistance					0.748		
Year around cropping season/ year around yield					0.546		
Low cost of labour						0.479	
Preferable by marketers						0.767	
Early maturity/Uniform maturity							0.848

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.[a]

According to Table 4, the rotated component matrix reveals seven key factors influencing farmers' decisions to grow tissue culture banana.

Table 5. Grouping of factors

S. No.	Benefits	Variables	Factor loadings	Mean score
1.	Plant Resilience and Uniformity	Quality of the plantlets	0.559	4.20
		High yield	0.232	4.08
		Drought Tolerant	0.790	3.60
		Disease resistance	0.721	3.50
		Tissue culture plants will be of same age and same variety	0.674	3.15
2.	Technological and Economic Support	Resistant to wind velocity	0.785	3.52
		Due to the adoption of drip irrigation technology	0.604	3.20
		Subsidy for planting Tissue culture Banana	0.718	3.08
		Good value in exporting of G9 Banana fruit	0.696	3.49
3.	Market and Resource Efficiency	Attractive yellow colour for local marketing	0.402	4.02
		Good keeping quality / shelf life	0.611	3.44
		Best in ratoon cropping	0.481	3.73
		Low cost of irrigation	0.539	3.39
4.	Fruit Quality and Consumer Preference	Weight of the finger is higher than the other variety	0.737	3.53
		Good taste, most preferable by consumers	0.668	3.77
5.	Crop Protection and Production Continuity	Insect resistance	0.748	3.58
		Year around cropping season/ year around yield	0.546	4.01
6.	Labour and Market Convenience	Low cost of labour	0.479	3.10
		Preferable by marketers	0.767	3.12
7.	Uniform and Early Harvest	Early maturity/Uniform maturity	0.848	4.01

Table 6. Benefits derived by farmers by growing tissue culture banana

S. No.	Factors	Mean score	Rank
1.	Uniform and Early Harvest	4.01	I
2.	Crop Protection and Production Continuity	3.79	II
3.	Plant Resilience and Uniformity	3.70	III
4.	Fruit Quality and Consumer Preference	3.65	IV
5.	Market and Resource Efficiency	3.64	V
6.	Technological and Economic Support	3.32	VI
7.	Labour and Market convenience	3.11	VII

Table 7. Principal component analysis

Total variance explained									
Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	Per cent of variance	Cumulative per cent	Total	Per cent of variance	Cumulative per cent	Total	Per cent of variance	Cumulative per cent
1	4.96	24.831	24.831	4.966	24.831	24.831	2.687	13.435	13.435
2	2.25	11.294	36.125	2.259	11.294	36.125	2.323	11.614	25.049
3	1.39	6.991	43.116	1.398	6.991	43.116	2.225	11.124	36.173
4	1.15	5.757	48.873	1.151	5.757	48.873	1.698	8.488	44.660
5	1.10	5.536	54.409	1.107	5.536	54.409	1.386	6.931	51.592
6	1.05	5.289	59.697	1.058	5.289	59.697	1.355	6.766	58.367
7	1.00	5.028	64.725	1.006	5.028	64.725	1.272	6.358	64.725
8	0.893	4.466	69.191						
9	0.847	4.233	73.424						
10	0.757	3.783	77.207						
11	0.736	3.679	80.886						
12	0.621	3.107	83.993						
13	0.561	2.804	86.797						
14	0.525	2.623	89.420						
15	0.501	2.504	91.924						
16	0.443	2.214	94.137						
17	0.406	2.031	96.168						
18	0.307	1.536	97.704						
19	0.278	1.390	99.095						
20	0.181	0.905	100.00						

Extraction Method: Principal Component Analysis.
From this extraction method of principal component analysis revealed seven key factors influencing adoption.

Plant Resilience and Consistency, with a mean score of 3.70 reflects farmers' recognition of the high quality of tissue culture plantlets, uniform growth patterns, and improved crop stand in the field.

Fruit Quality and Market Preference, which recorded a mean score of 3.65 captures the importance given to desirable physical traits such as fruit appearance, size, and overall consumer acceptability in the market.

Economic Viability and Input Efficiency, with a mean score of 3.64 highlights the perceived benefits related to reduced input needs, extended shelf life, potential for ratoon cropping, and enhanced overall profitability.

Institutional Support and Market Opportunities, scoring a mean of 3.32 represents the influence of factors such as access to government subsidies, linkage to export markets, integration with drip irrigation, and training support.

Labour and Distribution Ease, which had a mean score of 3.11 points to benefits related to reduced harvest labour, improved transportability, and better access to distribution and logistics channels.

Principal Component Analysis

Using SPSS software, Principal Component Analysis (PCA) was applied to extract underlying factors from 20 statements intended to identify key influences on the farmers decision to grow tissue culture banana. As shown in the Component Matrix, SPSS initially extracted all variables however, based on the eigenvalue criterion (greater than one), seven components were ultimately retained. The Extraction Sums of Squared Loadings column indicated that these seven components together explained around (64.72%) of the total variance values are presented in Table 7.

Scree plot

Scree plot was, used to determine the appropriate number of factors to retain. It serves as a visual representation eigenvalue versus all the benefits. The point of interest is a place where the curve begins to flatten and the graph plotted is explained in Fig.1.

It was clear from Fig.1. that the curve begins to flatten from seventh factor were 20 variables extracted were analyzed for further research.

The above findings show that while agronomic and economic factors play a dominant role in TCB adoption, institutional and logistical parameters are also crucial. Particularly, the factor "Institutional Support and Market Opportunities" scored lower, signalling a weak linkage between farmers and enabling institutions.

The study shows that farmers generally accept tissue culture banana (TCB) for its consistent yields, early harvests and good fruit quality. While most were satisfied with its agronomic benefits, challenges like pest issues, limited subsidies and weak extension support especially for marginal farmers remain concerns.

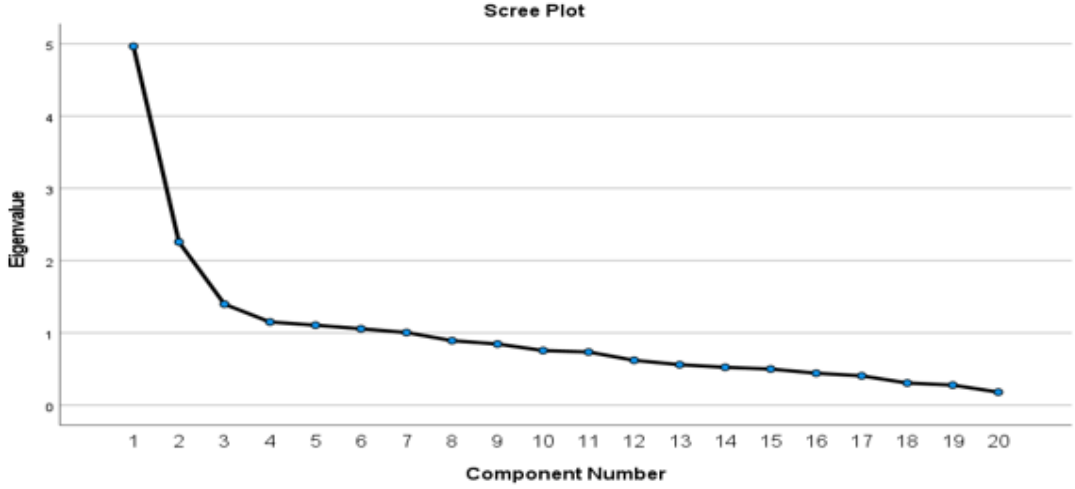


Fig. 1. Screen plot

Principal Component Analysis revealed seven key factors influencing adoption, highlighting both biological performance and institutional support. For wider and sustained adoption, it's essential to strengthen areas like pest management, timely input delivery and policy support. A balanced approach combining technology, infrastructure and government backing is crucial to expand TCB adoption across diverse regions.

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