Factors Influencing Adoption of Tissue Culture Banana (TCB) Technology Among Banana Farmers in Chitwan District, Nepal

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Abstract

The adoption of tissue culture banana (TCB) technology promotes resistance to diseases, increased competitiveness, and a commitment to sustainability in the banana subsector. An investigation was carried out during 2021 to identify the factors influencing the adoption of TCB technology among banana farmers in Chitwan district, Nepal. Randomly 65 farm household were selected to gather primary data using semi structured questionnaire, further Focus Group Discussion (FGD) and Key Informant Interview (KII) was carried with selected individuals. Descriptive statistics and probit model was used to present the findings. Result revealed that adoption of TCB technology is significantly affected by annual farm household income, access to subsidy and access to credit. Hence, extension agencies of government and non-governmental institutions should primarily focus on farm household having higher income and access to credit for better adoption. A comprehensive policy approach considering market dynamics and infrastructure development is essential while delivering subsidy.

Key words: subsidy, credit, income, market

Introduction

Bananas are a key dietary and economic resource in tropical and subtropical regions worldwide, contributing significantly to caloric intake, nutritional diversity, and income (Varma & Bebber, 2019; FAOSTAT, 2018). In Nepal, while bananas are traditionally grown for domestic use, commercialization is on the rise (Pandey et al., 2017), constituting 1.36% of the Agricultural GDP during 2021/22 (MoALD, 2022). Despite its potential, Nepal faces challenges in banana production, leading to a substantial demand-supply gap and reliance on imports. In the fiscal year 2019/20, Nepal imported 50,651,756 kg of bananas (MoF, 2019), due to low domestic productivity caused by various challenges, including diseases, pests, and a lack of quality saplings (Dave et al.,

2016; Phulara et al., 2020; S. Ghimire et al., 2019; Bhatta et al., 2023). Climate change further exacerbates these issues, impacting crop productivity and quality (Ghimire et al., 2016).

To address these challenges, the adoption of tissue culture banana (TCB) technology has emerged as a significant scientific advancement (Chandler, 1995). TCB is a biotechnological innovation widely embraced in commercial banana production (Bandewar et al., 2017), allowing for rapid and large-scale propagation of disease-free and uniform plants. Compared to traditional nursery suckers, TC bananas exhibit faster growth, early fruit production, and a shorter time to maturity (340 days compared to 420 days) (Africa Harvest Biotech Foundation International, 2008). The adoption of TCB has proven to enhance farm and household income, alleviate food insecurity, and create economic opportunities in developing countries (Acharaya & Mackey, 2009; Kabunga et al., 2014). Adoption of TCB technology increases farm and household income by 153% and 50%, respectively (Kabunga et al., 2011). The expansion of tissue culture technology not only increases food accessibility but also generates income, boosts tax revenue, and provides employment opportunities, particularly for women and young individuals (Wambugu et al., 2008). This technological shift holds promise for addressing production challenges, improving food security, and fostering economic growth in Nepal's banana industry. Hence, the study attempts to identify the factors influencing the adoption of tissue culture banana (TCB) technology to help develop strategies to maximize the adoption among farming communities.

Methodology

Study area, sampling technique and data collection

Chitwan district was purposively selected due to its significant role as a primary center for banana cultivation (Bhatta et al., 2023). Government initiatives such as the Banana Zone, implemented as part of the Prime Minister Agriculture Modernization Project (PMAMP), and the One Village One Product (OVOP) program have emphasized and prioritized banana production in Chitwan. The area coverage of banana farming is 2076 ha, production of 43193 Mt and Yield of 20.81 Mt/ha (MoALD, 2022). The promotion of TCB technology is being actively undertaken by PMAMP, Agriculture Knowledge Center (AKC), and municipalities, along with the involvement of I/NGOs. The survey specifically targeted the PMAMP command area, covering Khaireni, Ratnanagar, and Kalika municipality, as these areas host a significant concentration of banana farms. According to

the records from PMAMP Chitwan, there were a total of 423 registered farms/farmers in their office; which was population for our study during 2021. To calculate sample size, we used the formula (Daniel, 1999);

$$n = N*X / (X + N - 1),$$

Where,

$$X = Z_{\alpha/2}^2 *p*(1-p) / MOE^2,$$

and $Z_{\alpha/2}$ is the critical value of the normal distribution at $\alpha/2$, MOE is the margin of error, p is the sample proportion, and N is the population size.

Using sample random sampling, 65 farm households (Khaireni-10, Ratnanagar-20, Kalika-35) were selected. The sample size was further divided into adopters and non-adopters to TCB. Primary data was collected through face-to-face interviews with household heads, utilizing semi-structured questionnaires. Additionally, one Key Informant Interview (KII) and one Focus Group Discussion (FGD) were conducted in the aforementioned municipalities to enhance and complement the findings obtained from the household interviews. KII was carried out with progressive farmers and extension workers of government and non-governmental institutions. FGD was carried out with farmers. In-depth reviews of published reports from PMAMP Chitwan, AKC Chitwan, and other relevant institutions and authors were also carried out to gather secondary data.

Empirical model

Descriptive analysis was done using IBM SPSS Statistics 25. Similarly, *t*-test was done using IBM SPSS Statistics 25 to compare mean difference of adopters and non-adopters. Probit model was employed using Stata/SE 12.1 in order to determine the factors influencing the adoption of TCB technology among banana farmers. Further, to assess the effect of each independent variable on the adoption of TCB technology, marginal effect on those variables was estimated in the probit model.

Model specification

The probit model used in this study to analyze factors influencing the adoption of TCB technology among banana farmers is specified as follows;

$$Pr(Y = 1) = f(b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 + b_9 X_9 + b_{10} X_{10} + b_{11} X_{11} + b_{12} X_{12} + b_{13} X_{13})$$

Where,

Pr (Y = 1) = Probability of adoption of TCB technology

X_1 = Age (continuous)

X_2= Gender (dummy)

X_3 = Education (continuous)

X_4 = Farm size (continuous)

X_5 = Family involvement (continuous)

X_6 = Member in organization (dummy)

X_7 = Contact with extension worker (dummy)

X_8 = Income (continuous)

X_9 = Source of income (dummy)

X_{10} = Subsidy (dummy)

X_{11} = Training (dummy)

X_{12} = Farming experience (continuous)

X_{13} = Credit (dummy)

b_0 = Regression coefficient

b_1, b_2 . . . . . b_{13} = Probit coefficient

The description of the variables used is presented in Table 1.

Results and discussion

Descriptive statistics

Table 1 presents the descriptive statistics for the variables under consideration. It is evident from the data that 26% of the sampled households have adopted TCB technology, and a majority (85%) of these households is led by male heads. The average age of the household head is 48.46 years, and respondents, on average, have completed 10.35 years of formal schooling. The average farm size is 119.48 kattha, with an average of 2.78 household members involved in banana farming. The average household income is NPR 1895307.69, and respondents have an average farming experience of 8.20 years. Furthermore, on average, 75% of the respondents' households derive income solely from agriculture, 38% have participated in organizations, and 26% maintain regular contact with extension workers. Additionally, 29% of the respondents have access to subsidies, 51% have received training on TCB technology, and 32% have access to credit.

Table 1. Descriptive statistics of variables for adoption of TCB technology

Variable	Description	Mean	Standard Deviation
Dependent variable			
Adoption of TCB technology	=1 if respondent has adopted TCB technology, 0 otherwise	0.26	0.443
Independent variable			
Age	Age of respondent (year)	48.46	12.719
Gender	Gender of the respondent (1-male, 0-female)	0.85	0.364

Education	Formal education of respondent (year)	10.35	3.689
Farm size	Farm size under banana farming (kattha)	119.48	169.604
Family involvement	Family involvement in banana farming (number)	2.78	1.536
Member in organization	= 1 if respondent is member farmers groups or agriculture cooperatives, 0 otherwise	0.38	0.490
Contact with extension worker	=1 if respondent has regular contact with extension worker, 0 otherwise	0.26	0.443
Income	Annual income of household (NPR)	1895307.69	3214957.946
Source of income	=1 if respondent's household receive income from agriculture only, 0 otherwise	0.75	0.434
Subsidy	=1 if respondent has access to subsidy, 0 otherwise	0.29	0.458

Training	=1 is respondent have attended training on TCB technology, 0 otherwise	0.51	0.504
Farming experience	Respondent involvement in banana farming (year)	8.20	4.935
Credit	=1 is respondent have access to credit, 0 otherwise	0.32	0.471

Source: Field survey, 2021

Characteristics of adopters and non-adopters of TCB technology

Table 2 presents the outcomes of the mean differences in characteristics distinguishing those who have adopted TCB technology from those who have not. The analysis indicates notable distinctions in terms of access to subsidy, farming experience, and access to credit between adopters and non-adopters. Adopters consistently exhibited significantly higher values for all these variables when compared to their non-adopter counterparts.

Table 2. Characteristics of adopters and non-adopters of TCB technology

Variable	Adopter (n=17)	Non-adopter (n=48)	Mean difference	t value
Age	50.47	47.75	2.721	0.755
Gender	0.82	0.85	-0.031	-0.296
Education	11.53	9.94	1.592	1.546
Farm size	147.88	109.42	38.466	0.801

Family involvement	2.76	2.79	-0.027	-0.062
Member in organization	0.35	0.40	-0.043	-0.308
Contact with extension worker	0.24	0.27	-0.036	-0.282
Income	2248823.53	1770104.17	478719.363	0.525
Source of income	0.71	0.77	-0.065	-0.527
Subsidy	0.76	0.13	0.640	6.241***
Training	0.53	0.50	0.029	0.205
Farming experience	9.94	7.58	2.358	1.719*
Credit	0.82	0.15	0.678	6.556***

Source: Field survey, 2021

Note: *, *** indicate significant at 10%, 1% level of significance, respectively.

Factors influencing adoption of TCB technology in the study area

Table 3. Probit regression analysis and marginal effect for factors influencing the adoption of TCB technology

Variable	Coef.	SE	p value	dy/dx	SE(dy/dx)
Age	0.046	0.036	0.208	0.008	0.007
Gender	-1.137	1.068	0.287	-0.305	0.369
Education	0.086	0.135	0.521	0.015	0.025
Farm size	-0.003	0.003	0.264	-0.0006	0.0006

Family involvement	0.160	0.224	0.477	0.028	0.037
Member in organization	0.348	0.988	0.725	0.065	0.191
Contact with extension worker	-0.980	0.959	0.307	-0.132	0.103
Income	2.674**	1.177	0.023	0.476	0.227
Source of income	-1.048	0.788	0.184	-0.252	0.221
Subsidy	-2.402*	1.415	0.090	-0.283	0.150
Training	0.168	0.666	0.801	0.029	0.117
Farming experience	0.085	0.086	0.321	0.015	0.015
Credit	0.988***	0.032	0.000	0.988	0.032
_cons	-19.826	7.877	0.012		
Summary statistics					
Number of observations = 65					
LR chi^2 = 45.00					
Prob > chi^2 = 0.0000					
Pseudo R^2 = 0.6023					
Log likelihood= -14.8537					

Source: Field survey, 2021

Note: *, **, *** indicate significant at 10%, 5%, 1% level of significance, respectively.

Factors influencing adoption of TCB technology is presented in Table 3. The likelihood ratio chi-square (LR chi2) for the model was statistically significant at 1 percent level of significance. Result showed that farm household income, access to subsidy and credit was statistically significant in the adoption of TCB technology. Keeping other variables constant, the probability of adopting TCB technology increases by 47.6 percent if the income of the farm household increases by one unit. Farmers with higher incomes are more likely to afford the initial costs associated with investing in TCB technology. Additionally, their elevated income levels may contribute to a higher risk tolerance, fostering a greater willingness to experiment with new technologies that offer long-term benefits. Moreover, these higher-income farmers may enjoy enhanced access to resources, including credit, thereby facilitating the adoption of innovative technologies. Result is in line with Ndungu Thuo et al. (2007). Keeping other variables constant, probability of adoption of TCB technology decreases by 28.3 percent if respondent has access to subsidy. The lack of sufficient information and skills among farmers may lead to a failure to recognize the value of adopting TCB technology, even in the presence of available subsidies. Additionally, the specific infrastructure or resources required for TCB technology may be lacking among farmers who have access to subsidies. Concerns regarding the initial investment, maintenance, or uncertainties in the market could serve as deterrents to the adoption of TCB technology, even when subsidies are accessible. Keeping other variables constant, probability of adoption of TCB technology increases by 98.8 percent if respondent has access to credit. Access to credit strengthen risk tolerance capacity of farmers and provide essential financial resources to invest in new technologies, facilitating the construction and improvement of the infrastructure required for the successful implementation of TCB technology, thereby enhancing its feasibility for farmers. Result is similar to previous findings (Muyanga, 2009; Omari et al., 2023).

Conclusion

Tissue culture banana (TCB) technology has the potential to enhance productivity and promote the commercialization of the banana subsector in Nepal. Despite its benefits, the adoption of this innovation among farming communities remains limited. The study findings revealed that adoption of TCB is significantly and positively affected by annual household income. Hence, extension agencies of government and non-governmental institutions are advised to prioritize their efforts on farms with higher incomes for better adoption. Moreover, adoption of TCB is

significantly and negatively affected by access to subsidies. This suggests a need for a comprehensive approach to restructuring of policy and program related to subsidy, through incorporating considerations for market dynamics and infrastructure development. Similarly, adoption of TCB is significantly and positively affected by access to credit. Hence, extension agencies of government and non-governmental institutions should primarily focus on farms with access to credit.

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