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Predicting farmers' adoption of genetically modified vegetable crops in India: An *ex-ante* assessment of *Bt*-brinjal adoption behaviour and its determinants

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ABSTRACT

An *ex-ante* study was carried in *Karnataka* and *Andhra Pradesh* during the year 2014-15 to assess the farmers' *Bt*-brinjal adoption decision and its determinants. Data was collected on the aspects of *Bt*-brinjal adoption decision and its potential determinants from 120 farmers. Adoption behaviour prediction model was developed using logistic regression. It was found that majority of farmers (61.67%) were willing to adopt *Bt*-brinjal, if released in future. It was also found that health risk perception (β = -0.113, $p < 0.01$) and socio-economic risk perception (β = -0.127, $p = 0.02$) negatively influence the farmers willingness to adopt *Bt*-brinjal, whereas past experience in cultivation of agrobiotech crops (β = 2.01, $p = 0.017$) was found to have significant positive influence on adoption decision. Interestingly, factors like regulatory, ethical, environmental and biodiversity risk perception have no significant influence on the farmers' adoption decision for *Bt*-brinjal. Based on this study, we concluded that from policy perspective for successful adoption, genetically modified (GM) vegetable crops must be first introduced in the areas where GM crops (*i.e.* *Bt*-cotton) are already under cultivation and efforts should be made to reduce the health and socio-economic risk perception among the farmers.

Key words: *Solanum melongena*, shoot and fruit borer, GM crops, farmers adoption perception.

INTRODUCTION

Brinjal is an important vegetable crop consumed across India. Around 680 thousand hectare area is under brinjal cultivation in India with total production of 12.44 million tonnes (Anonymous, 2). Even though India ranks next to China in brinjal production, its productivity is far lower (Anonymous, 1). In India brinjal is infested by numerous insect pests, the most destructive of which is the Brinjal shoot and fruit borer (ESFB, *Leucinodes orbonalis* Guen.). Despite heavy insecticide applications, significant yield losses occur in brinjal (Ghosh et al., 5). Past studies have consistently shown that insect-resistant *Bt* (*Bacillus thuringiensis*) crops can bring about sizeable reductions in pesticide usage and gains in productivity (Krishna and Qaim, 7). From past studies (James, 6; Francisco, 4; Krishna and Qaim, 7) it is also obvious that transgenic crops have potential to contribute towards ensuring food security. In spite of its potentiality, the *Bt*-brinjal is still framed in the society as a technology with lot of uncertainties.

However, the ray of hope for commercialization of transgenic food crops has emerged once again with the recent progress made in commercialization of GM Mustard. Not just the *Bt*-brinjal, but many more vegetable crops will fall in line, if the commercialization of *Bt*-brinjal turns out to be a successful venture in future. But prior to commercialization, assessment of farmers' and consumers' acceptability of genetically modified food crops is a prerequisite task. Many studies till date have investigated the consumers' acceptability of GM technology (Poortinga and Pidgeon, 8; Verdurme *et al.*, 10; Siegrist, 9; Christoph, 3) but there are no empirical studies conducted in India that made an attempt to predict the farmers' acceptability of the GM food crops and model their adoption behaviour. Keeping this need in background an *ex-ante* study was conducted to identify the potential determinants of *Bt*-brinjal adoption behaviour, quantify their influence and develop a model for predicting *Bt*-brinjal adoption behaviour. This study will be instrumental not only in predicting the farmers' adoption behaviour but also in developing strategies to create favourable situation for enhanced adoption of transgenic vegetable crops in future.

MATERIALS AND METHODS

The study was conducted in the Karnataka and Andhra Pradesh during 2014-15 on 120 farmers who were cultivating brinjal either in the current season or in past seasons. Of these 120 farmers, 60 were already cultivating an agrobiotech crop (either *Bt*-cotton/ tissue cultured banana) and 60 farmers were cultivating conventional crops. For development of the prediction model, farmers' *Bt*-brinjal adoption decision (Yes/No) was considered

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as the outcome variable and socio-psychological and demographic variables like age, education level, farming experience, past experience in cultivation of agrobiotech crops, scientific orientation, cosmopoliteness, economic achievement motivation, health risk perception, ethical risk perception, environmental and biodiversity risk perception, regulatory risk perception and socio-economic risk perception were considered as possible determinants. Various dimensions of risk perception were measured by using the Likert scales developed as a part of this study. Schedule was developed to measure economic achievement motivation, cosmopoliteness and scientific orientation. Data on these variables was collected from farmers by using personal interview method. Collected data was analysed by using Univariate Generalized Linear Model (Logistic Regression) in SPSS® *Statistics 23*.

RESULTS AND DISCUSSION

The preliminary results of the study revealed that in overall a majority of the farmers (61.67%) were willing to cultivate *Bt*-brinjal crop, if introduced in future, whereas slightly more than a third (38.33%) of the respondents were not willing to adopt GM crops. Additionally, preliminary observations also revealed that the proportion of farmers who were willing to adopt *Bt*-brinjal were relatively higher in case sub-sample farmers who had past experience in cultivation of agrobiotech crops (81.67%), as compared to farmers in sub-sample with no past experience in cultivation of agrobiotech crops (61.67%).

Since our interest was to predict the adoption behaviour of the farmers, the data collected on the socio-psychological and demographic variables were subjected to logistic regression analysis with farmers' decision to adopt *Bt*-brinjal (Yes/No) as the outcome variable. The results of the analysis are presented in Table 2-6.

First parts of the results of the analysis include the prediction Model-I, which do not consider the potential predictors for model development. Second part consists of model summary for prediction Model – II which includes all the predictor variables, classification table for prediction Model-II, overall model fit, classification table for prediction Model-II and lastly the variables in the model which consists of log odds, odds ratio and their significance.

Prediction Model-I. This model predicts the farmers' adoption decision without considering the potential predictors which we are intended to investigate. The results (Table 1) indicate that even without the potential predictors' information a statistically significant predictor model can be developed just by considering the constants. Subsequent model includes the potential predictors into the model.

Prediction Model-II. This model is developed after including the potential variables under investigation. Since the outcome variable in this study is categorical in nature, it is not possible to compute a single coefficient of determination that has all of the

Table 1. Cross-tabulation of farmers' adoption decision across sub-samples.

Type of farmer	*Bt*-brinjal adoption decision		Total
	No	Yes	
Past experience in cultivation of GM crop (No)	35 (58.33)	25 (41.67)	60
Past experience in cultivation of GM crop (Yes)	11 (18.33)	49 (81.67)	60
Total	46 (38.33)	74 (61.67)	120

*Figures in the parenthesis indicate the percentage of sub-sample/ entire sample

Table 2. Prediction model without selected variables (Prediction Model-I).

	B	S.E.	Wald	Significance value (*p*)	Exp (β)
Constant	0.475*	0.188	6.412	0.011	1.609

*Significant at 1% level

Table 3. Predictability measures for Model-II.

-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
80.027	0.485	0.660

Table 4. Hosmer and Lemeshow's test for statistical validation of model.

Step	Chi-square	Significance value (*p*)
1	4.813	0.232

Table 5. Classification table for prediction Model-II.

Observed		Predicted		
		Bt-brinjal adoption decision		Correct (%)
		No	Yes	
Bt-brinjal adoption decision	No	38	8	82.60
	Yes	8	66	89.20
Overall (%) accuracy of model				86.70

characteristics of the R^2 in the linear regression model, so the approximations are computed instead. Table 3 represents the Pseudo R square measures - Cox and Snell's R^2, Nagelkerke's R^2 and -2 Log likelihood for prediction model II. From the higher values of these pseudo R square measures (≥ 0.45) it can be interpreted that developed model have significantly high level of fit with the observed values and hence acceptable.

Statistical validation of prediction model –II: In order to test the significance of the overall model fit, we utilised the Hosmer and Lemeshow's test. Non-significant Chi-square value in Hosmer and Lemeshow's test [X^2 (8, n = 120) = 4.813, $p > 0.05$] indicates that these is no significant variation between actual and predicted values of *Bt*-brinjal adoption decision of the farmers and hence concluded that we have generated a prediction model that have acceptable level of fit and hence it is acceptable for prediction purpose (Table 4).

The second classification table which is based on the model including the predictors under investigation revealed that the overall percentage of correct predictions were 86.70%. Based on the findings first and second classification table, we can conclude that percentage of correct prediction increased by 25.00% (Table 5) after including the said variables into the model.

Table 6 depicts the regression coefficients (log odds), Wald χ^2 value and respective p values for the log odds and the likelihood ratio (exponential of log odds). Regression coefficient (β) in the present study can be interpreted as the measure of increase / decrease in log odds of adoption of Bt- brinjal with every unit of change in the predictor variable. Odds ratio indicate extent to which the odds of adopting *Bt*- brinjal increase (or decrease) with a unit change in explanatory variable. Odds ratios (the exponentials of log odds) can be interpreted as the amount by which the likelihood of adoption of *Bt*-brinjal increases / decreases with every unit of change in predictor variable.

Based on the findings form Table 6 it was concluded that, the past experience in cultivation of agrobiotech crops (β = 2.017, $p = 0.017$) is the strongest determinant of farmers adoption decision for Bt-brinjal crop. It influences the adoption decision positively. If a farmer has cultivated agrobiotech crops in past, then the likelihood of adoption of *Bt*-brinjal increases by a factor of 7.513. Socio-economic risk perception (β = -0.127, $p = 0.029$) and health risk perception (β = -0.113, $p = 0.005$) were also found to significantly influence the farmers' decision of adoption/rejection of Bt- brinjal) but in a negative manner. With every unit increase in the health risk perception score, the likelihood of adoption of *Bt*-brinjal decreases by a factor of 0.893. Similarly, with every unit increase in the socio-economic risk perception, the likelihood of adoption of the *Bt*-brinjal decreases by a factor of 0.881.

Interestingly, it was found that factors like age (β = -0.296, $p = 0.22$), education (β = 0.394, $p = 0.26$), farming experience (β = 0.317, $p = 0.21$), cosmopoliteness (β = 0.320, $p = 0.18$), scientific orientation (β = 0.196, $p = 0.33$), economic achievement motivation (β= -0.318, $p = 0.13$), environmental and biodiversity risk perception (β = -0.028, $p = 0.50$), regulatory risk perception (β = 0.010, $p = 0.85$) and ethical risk perception (β = 0.056, $p = 0.31$) had

Table 6. Regression coefficients for the predictor variables and their significance.

	Co-efficient (β)	Wald	*p* value	Exp (β) #
Age	-0.296	1.46	0.227	0.744
Education	0.394	1.23	0.268	1.482
Farming experience	0.317	1.58	0.210	1.373
Past experience in cultivation of agrobiotech crops	2.017*	5.70	0.017	0.133
Cosmopoliteness	0.320	1.75	0.186	1.378
Scientific orientation	0.196	0.95	0.331	1.217
Economic achievement motivation	-0.318	2.29	0.130	0.727
Health risk perception	-0.113*	8.03	0.005	0.893
Socio-economic risk perception	-0.127**	4.77	0.029	0.881
Environmental and biodiversity risk perception	-0.028	0.44	0.508	0.973
Regulatory risk perception	0.010	0.04	0.850	1.010
Ethical risk perception	0.056	1.04	0.307	1.058
Constant	7.527	4.27	0.039	1858.362

Exponential values of regression coefficients; *,** significant at 1 and 5% level.

no significant role to play in determining adoption/ rejection of agrobiotech crops by the farmers.

Based on the results, we can conclude that chances of adopting *Bt*-brinjal increase when the farmers have cultivated agrobiotech crops in the past and perceive lower health and socio-economic risk from agrobiotech crops. Whereas, the farmer who have not cultivated agrobiotech crops in past and perceives relatively higher health and socio-economic risks from agrobiotech crops are less likely to accept and adopt *Bt*-brinjal. In the areas where transgenic crops are not under cultivation efforts should be directed towards capacity building and developing scientific know-how among farmers about the socio-economic benefits and nutritional values associated with transgenic food crops. Additionally, extension interventions like field demonstrations and field days on transgenic crops must be utilized extensively, especially in the regions where no transgenic crops are under cultivation till date. These efforts will help in minimizing the health and socio-economic risks perceived from transgenic crops.

Hence from the strategic planning point of view, efforts should be made to reduce the perceived health and socio-economic risks from GM vegetable crops. Additionally, for successful adoption newer agrobiotech crops including genetically modified vegetables must be initially introduced among the farmers who have past experience in cultivation of agrobiotech crops.

As reported in Table 1 & 6, the Model I predictability without including variables under investigation is considerably higher and our model was able to improve prediction by 25%. This indicates that there are many other significant variables that influence the farmers' adoption decision but are not considered in this study. Hence, future research must focus on exploring the additional variables that influence the farmers' decision about adoption of *Bt*-brinjal. In order to generalize the findings of this study, further research should be carried out using similar approach but with different crop and locality.

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