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Research Article

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Farmers' Income and Adoption Determinants of Organic Bean Farming: Evidence from Narsingdi District, Bangladesh

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ABSTRACT

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The growing demand for organic vegetables in Bangladesh underscores the need to evaluate the profitability of organic versus inorganic country bean production. This study applied an endogenous treatment effect model to compare the income of organic and inorganic bean growers. Research was conducted in Monohardi Upazila of Narsingdi district, a prominent vegetable-producing region, using data collected through interviews with 100 organic and 100 inorganic farmers. Findings reveal that organic bean growers had an average age of 43.94 years and 25.38 years of farming experience, while inorganic growers averaged 44.06 years of age and 27.43 years of experience. Inorganic farmers reported more frequent contact with extension workers (65 contacts annually) compared to organic farmers (60 contacts). Conversely, organizational participation was markedly higher among organic growers (98%) than inorganic growers (56%). The endogenous treatment effect model showed that conventional farming methods generated a 22.9% higher gross margin compared to organic methods. Gross margin was significantly influenced by household size and organizational participation. Moreover, bean yield, farmers' age, farming experience, and organizational involvement emerged as critical factors shaping the decision to adopt organic or inorganic production practices. Overall, the study highlights that while conventional methods currently offer higher profitability, organizational participation and socio-economic characteristics strongly influence farmers' production choices. These findings provide valuable insights for policymakers and extension services aiming to balance profitability with sustainability in Bangladesh's vegetable sector.

INTRODUCTION

Vegetables play a vital role in the daily diet of Bangladeshi people, as they are an affordable source of essential vitamins and minerals. The critical role of vegetables in the human diet stems from their provision of key nutrients, including vitamins, minerals, and fiber that are vital for maintaining health (Rana and Rahaman, 2021). Bangladesh ranks as a top vegetable producer among developing nations, and its rising productivity is crucial for securing nutrition and food for its growing population (Yeasmin, 2016). Vegetables help to minimize malnutrition as well as maximize financial returns of farmers (Karim *et al.*, 2021).

Vegetables are grown all over Bangladesh and most of the vegetable's growers are small and marginal farmers. Most vegetable growers are small-scale or marginal farmers who are severely impacted by production and price risks. In recognition of vegetables' significance, the government of Bangladesh has implemented technical support programs to enhance vegetable yields (Khatun *et al.*, 2022). However, a significant challenge remains, as farmers often apply excessive chemicals; more alarmingly, some apply them immediately before harvest to make the produce appear pest-free, posing a serious health risk (Parveen *et al.*, 2023).

Organic farming is still in its initial stages in Bangladesh, facing several significant challenges that hinder its widespread adoption. Food security remains a major concern in transitioning from conventional farming, and there is a notable lack of awareness about organic practices among farmers and low recognition of organic production among consumers. Consequently, organic products are not yet popular, and an organized supply chain for them is not well-developed. A primary obstacle is the lack of expertise in organic farming techniques, which has excluded Bangladeshi farmers from the global organic market, stifled domestic market development, and obstructed progress toward more sustainable agricultural systems (Farouque and Sarker, 2018). Furthermore, due to the greater short-term profitability of conventional farming, a swift transition to organic practices is unlikely (Murshed and Uddin, 2020). This conventional system is bolstered by government subsidies on key inputs like chemical fertilizers, electricity for irrigation, and mechanized equipment, which are offered to boost overall production and bolster food security.

Despite these challenges, a growing interest in organic food is emerging, with increasing numbers of both producers and buyers, even though the producer base remains small (Iqbal, 2015). According to Ferdous *et al.*, (2021), 13,903 hectares of land are under organic cultivation, representing about 0.1% of the total agricultural land. The interest is driven by the significant multi-faceted benefits organic agriculture offers. Organic farming is a prominent practice advocated to mitigate the adverse impacts of chemical farming, such as pollution, soil health decline, hazards to human health, and ecosystem degradation (Ghosh *et al.*, 2019). According to Karim (2018) organic farming offers significant advantages, including enhanced biodiversity, reduced environmental degradation, and better integration of growers into high-value food supply chains.

Ultimately, organic agriculture encompasses social, economic, and environmental dimensions, all of which contribute to improved long-term food security (Morshedi *et al.*, 2017). With its foundation in sustainability and environmental stewardship, it can yield significant economic, social, and environmental benefits for disadvantaged communities (Sarker *et al.*, 2021). Therefore, despite the premium prices charged for organic foods, the associated holistic benefits are often greater than the immediate financial cost (Fillion & Arazi, 2002).

Beans are an economically and nutritionally crucial crop across all global regions (Hayat *et al.*, 2015). In Bangladesh, the bean or "Sheem" as it is known locally, is a common vegetable and its main cultivation season is winter (Rabi), but it is also grown to a lesser extent in the summer (Kharif) (Biswas, 2015). The high consumer demand for beans is driven by their role as an affordable, protein-rich food, making them a key component of the country's fresh vegetable production (Rahman *et al.*, 2022). This importance is reflected in its scale of cultivation, with 63,268.45 acres yielding 226,330.84 metric tons in the 2023–2024 season (BBS, 2024).

Country bean farmers employ both conventional and organic techniques. While conventional methods rely on synthetic fertilizers and pesticides to maximize yield, organic practices utilize natural alternatives. This dependence on agrochemicals, however, degrades soil health and pollutes the environment, posing a significant long-term threat to food safety and food security.

Bean farming in Bangladesh, due to its risk and inefficiency, threatens the bean supply, consumption pattern, and farmers' livelihoods (Musyoki *et al.*, 2022). Rahman *et al.*, (2022) found that pest infestations, insect, and disease significantly impact bean production. Moreover, Alam *et al.*, (2018) identified the primary challenges for bean farmers in Bangladesh as a lack of capital, insufficient storage, limited access to fertilizers and pesticides, inadequate irrigation, unfavourable climate conditions, and price fluctuations. Consequently, while research concludes that bean production can be profitable in Bangladesh, the socio-economic characteristics of the farmers are inversely related to the degree of problems they face (Hasan *et al.*, 2014).

The Narsingdi district is renowned for its vegetable production, particularly its beans. Organic bean farming is not yet widespread in the Narsingdi district of Bangladesh. Local farmers are skeptical about its adoption due to uncertainties regarding the organic market, price premiums for their produce, and consumer demand. Research is needed to analyze the profitability of organic bean farming and to determine the key factors that motivate farmers to adopt organic bean farming in the Narsingdi district of Bangladesh.

A significant gap exists in the comparative evaluation of commercial organic and conventional bean farming systems in Bangladesh, particularly regarding their profitability. This research evaluates the effect of organic bean cultivation on farmer income and examines the principal determinants affecting its adoption by farmers in in the Narsingdi district of Bangladesh.

MATERIALS AND METHODS

Selection of the study area and the sample

Narsingdi district is a leading vegetable producing district in Bangladesh and this district is selected for the present study. Four villages namely Charmandalia, Nayapara, Montala, and Khidirpur under Monohardi upazila of Nasingdi district were selected for the data collection. A full list of farmers was collected from the upazila agriculture office and this list constitute the sampling frame of the present study. 25 inorganic bean growers and 25 organic bean growers were selected from each village. For the purpose of this study, a random sample of 200 country bean farmers was selected, comprising 100 organic and 100 conventional producers.

Interview schedule and data collection procedure

Primary data were gathered via personal interviews, employing a pre-tested interview schedule. Interview schedule was improved and modified after pretesting. Data were collected from February to March 2021. Researcher himself was collected and clean the data. After collecting the data, the data were inserted in Excel sheet. STATA 15 was used for analysis the data. The data analysis and presentation were conducted primarily using descriptive statistics.

Farming decision to adopt organic bean farming (Selection equation)

The adoption decisions of farmers regarding organic country bean cultivation can be modeled using a latent variable approach, where the probability of adoption depends on a set of observed farmer-specific variables:

$M_i{*}= \beta P_i + u_i$ equation (i)

$M_i{*} = 1$, if $M_i{*} > 0$ otherwise, $M_i = 0$

Where M denotes the dependent variable. M is a binary variable equal to 1 if the farmer adopts an organic country bean farming system, and 0 otherwise; the vector β represents the parameters to be estimated, while P_i comprises all observable farm-level characteristics of the farmer that may influence the adoption decision. The independent variables comprise a set of farm-level and socio-demographic characteristics, including bean yield, respondent age, household size, years of schooling, training attendance, farm size, frequency of extension contact, participation in farmer organizations, and farming experience. A detailed description of the variables employed in the model is provided in Table 1. The error term is denoted by u_i.

The effect of organic bean farming on farmer's gross margin (Outcome equation)

This analysis assesses the economic implications of organic farming, specifically its impact on gross farmer income. The outcome variable, being a linear function of observed characteristics at both the farm and farmer level, is expressed as follows:

$K_i = \alpha O_i + \eta M_i + e_i$ equation (ii)

Here, K_i denotes the vector of the outcome variable, gross margin, while M_i—as defined previously in equation (i), is the binary indicator for the farming system; O_i is a vector containing the following observed characteristics of the farm and the farmer: bean farming, bean yield, age, household size, education level, farm size, number of trainings, extension contact, organizational participation, and farming experience; α and η represent coefficient vectors whose values are to be estimated; The term e_i captures the unobserved random component.

The parameter estimate for η in equation (ii) quantifies the impact of adoption on the outcome variable. In this approach, though, is susceptible to biased estimates due to the non-random nature of farmers' adoption decisions. This self-selection problem arises when unobserved factors, captured by the error term e_i in equation (ii), are correlated with the error term u_i in equation (i).

Consequently, the non-zero correlation between the error terms renders Ordinary Least Squares (OLS) estimates biased and inconsistent. The Propensity Score Matching (PSM) method is frequently employed to address this issue of selection bias. A significant limitation of the PSM methodology, however, is its inability to account for unobserved confounding variables. This study employs the Endogenous Treatment Effect Model, following the methodology of Mekonnen (2017), to concurrently estimate the factors influencing the adoption of farming systems and their subsequent impact. This approach explicitly accounts for endogeneity by controlling for both observable and unobservable confounding factors.

Endogenous treatment effect model

The Endogenous Treatment Effect Model is used to estimate the Average Treatment Effect (ATE) alongside the parameters of a linear regression that incorporates an endogenous binary-treatment variable. Using Full Information Maximum Likelihood (FIML) for estimation, the model is specified through two sets of equations:

The equation determining selection is specified as follows: $M_i{*}= \beta P_i + u_i$, equation (i) $M_i{*} = 1$, if $M_i{*} > 0$ otherwise, $M_i = 0$

The outcome is determined by the following equation: $K_i = \alpha O_i + \eta M_i + e_i$ equation (ii)

Where M_i is a binary indicator variable that equals 1 if farmer i adopts the organic farming system, and 0 otherwise and K_i represents the outcome variable, which is observed for all participants, regardless of their farming system (i.e., for both $M_i = 1$ and $M_i = 0$). O_i comprises a vector of observable farm and farmer characteristics. The parameters comprising vectors α and η are estimable from the model. e_i represents the model's disturbance term.

$Prob\ (M_i = 1 \mid P_i) = \Phi\ (P_i\beta)$

and

$Prob\ (M_i = 0 \mid P_i) = 1- \Phi(P_i\beta)$

The distributional assumption for the errors e_i and u_i is a bivariate normal with mean zero and a given covariance matrix $\begin{bmatrix} \sigma 2 & \rho\sigma \\ \rho\sigma & 1 \end{bmatrix}$. Here, σ^2 denotes the variance of the error term e_i from equation (ii), while the variance of u_i in equation (i) is supposed to unity (1). The covariance between e_i and u_i is represented by $\rho\sigma$.

Table 1: Detail description of the variable used in the model

Variables	Description
Dependent variable:	
Gross margin	Gross margin is the outcome of total revenue minus total variable cost production. Gross margin is expressed in Taka.
Bean farming system	Dummy variable. If farming system is organic = 1, otherwise 0.
Independent variables:	
Bean yield	Bean yield expressed in kg/ha
Age	Age of the respondent farmer in year
Education level	Years of schooling of the respondent farmer
Household size	Total family member of the respondent farmer
Farm size	Farm size is in decimal
Frequency of trainings received	Total number of trainings received by the farmer in a year
Extension contacts	Dummy variable. If farmer contact with extension worker = 1, otherwise 0.
Farming experience	Farmer farming experience in years
Organizational participation	Dummy variable. If farmer has any organizational participation = 0, otherwise 0.

RESULTS AND DISCUSSION

Results

Different characteristics of organic and inorganic bean producer in the study area

Table 2 summarizes the demographic profiles of organic and inorganic bean producers. The mean age was nearly identical between the two groups, at 43.94 years for organic producers and 44.06 years for inorganic producers. However, a slight difference was observed in household size: organic producers had an average of 3.5 members per family, while their inorganic counterparts averaged 3.83. Organic bean growers had an average homestead area of 8.84 decimals, which was smaller than the inorganic growers' average of 11.31 decimals. In contrast, organic growers cultivated a larger average farm size (119.74 decimals) compared to their inorganic counterparts (109.94 decimals).

Organic bean growers received more agricultural training per year (0.77 sessions) than inorganic growers (0.53 sessions). However, inorganic growers had slightly more frequent contact with extension services (65.0 vs. 60.0 contacts per year) and reported more farming experience (27.43 years vs. 25.38 years).

A substantial gap was observed in organizational participation, with 98.0% of organic growers involved in different organization compared to only 56.0% of inorganic growers. Access to information sources was high across both groups: all farmers had mobile phones and access to television, though slightly more inorganic farmers had TV access (100% vs. 99.0%). Similarly, while all inorganic growers had mobile internet, the rate among organic growers was also very high at 97.0%.

Access to digital agricultural tools was extremely limited but exclusive to organic growers, with only 0.06% utilizing mobile agricultural apps; no inorganic growers reported using them. Furthermore, organic growers' homesteads were located, on average, a greater distance from the local market (1.0 km) compared to those of inorganic growers (0.85 km).

The two groups showed distinct patterns in seed choice, despite similar physical access to agricultural resources—both had an average distance of 10.97 km to the agricultural office. A stark contrast emerged in the use of hybrid seeds: only 8.0% of organic growers used them, compared to 68.0% of inorganic growers. Furthermore, organic growers reported spending more time engaging with neighbouring farmers (145.8 minutes) than inorganic growers (123.0 minutes).

Table 2: Different characteristics of organic and inorganic bean producer in the study area

Items	Organic grower	Inorganic grower
Age (years)	43.94	44.06
Number of family members	3.50	3.83
Homestead area (in decimal)	8.84	11.31
Average farm size (in decimal)	119.74	109.94
Yearly agricultural training frequency	0.77	0.53
Yearly frequency of extension contacts	60.0	65.0
Farming experience (in years)	25.38	27.43
Membership in organization (%)	98.0	56.0
Television ownership and access (%)	99.0	100.0
Mobile phone ownership and access (%)	100.0	100.0
Internet connection in the mobile phone (%)	97.0	100.0
Use of agricultural apps in the mobile phone	0.06	-
Distance to nearest market (km)	1.0	0.85
Distance to agricultural office (km)	10.97	10.97
Hybrid seed utilization (%)	8.0	68.0
Time spent with fellow farmers (minutes/day)	145.8	123.0

Source: Farmer's household survey, 2021

Impact of organic bean farming on farm income and factors responsible for farmers to adopt organic bean farming

Table 3 shows the major factors affecting the gross margin of bean farming in the study area. Within the outcome equation, the coefficients for bean farming, household size, and participation in an organization are all statistically significant. Bean farming has a statistically significant negative coefficient of -0.229 at the 1% level. Ceteris paribus, farmers using inorganic methods for bean cultivation achieve a gross margin that is 22.9% higher than that of organic bean growers. Furthermore, household size exhibits a statistically significant negative coefficient at the 10% level. This result indicates that a larger household size is associated with a 2.5% higher gross margin for inorganic bean farming compared to organic production. Furthermore, participation in farmer organizations has a positive and statistically significant coefficient. Specifically, such participation is associated with a 14.8% increase in the gross margin for organic farming over inorganic bean farming.

The selection equation indicates that bean yield, farmer age, farming experience, and organizational participation were all statistically significant. The coefficient for bean yield is negative and significant at the 1% level. This result indicates that a higher yield from inorganic bean farming is associated with a 0.1% increase in the probability of adopting conventional farming methods. This result indicates a positive and statistically significant (at the 5% level) relationship between farmer age and the adoption of organic farming. Specifically, a one-unit increase in the age of the respondent is associated with a 5.3% increase in the probability of adoption of organic farming. The coefficient for farming experience is negative and significant at the 5% level. This indicates that more experienced farmers are more likely to adopt inorganic farming, with the probability increasing by 4.9% for each unit increase in experience.

The coefficient for organizational participation is positive and statistically significant at the 5% level. This result indicates that farmers who are members of an organization have an 8.3% higher probability of adopting organic farming practices.

Table 3: The endogenous treatment effect estimates for country bean production in the study area

Items	Outcome equation (ii)			Selection equation (i)		
	Coefficient	Robust SE	P value	Coefficient	Robust SE	P value
Dependent variable:	Log of gross margin			Bean farming (organic=1)		
Bean farming (organic=1)	-0.229***	0.032	0.000	-	-	-
Bean yield	-	-	-	-0.001***	0.0001	0.000
Age	-0.002^{NS}	0.003	0.583	0.053**	0.023	0.023
Education	0.004^{NS}	0.003	0.199	0.023^{NS}	0.018	0.218
Household size	-0.025*	0.013	0.058	-0.050^{NS}	0.074	0.500
Farm size	0.000^{NS}	0.0002	0.476	-0.001^{NS}	0.001	0.496
Number of trainings received	0.037^{NS}	0.031	0.237	0.277^{NS}	0.166	0.096
Extension contacts	-0.006^{NS}	0.019	0.752	-0.075^{NS}	0.10	0.455
Farming experience	0.002^{NS}	0.003	0.542	-0.049**	0.024	0.049
Organizational participation	0.148**	0.070	0.032	0.837**	0.400	0.039
Constant	12.158***	0.10	0.000	10.924***	1.26	0.000
Model diagnostic statistics:						
Sample size	200					
Log pseudolikelihood	-25.32					
Wald chi^2	58.59					
Probability of chi^2	0.000					
rho	0.89					
sigma	0.23					
lambda	0.21					
Wald test of independent equations (rho=0): Chi^2 (1) = 58.91						

Source: Farmer's household survey, 2021

Note: NS means not significant, ***, ** and * indicates significance at the 1%, 5% and 10% levels respectively

DISCUSSION

Average age of inorganic bean producer was higher than the organic bean producer. Average family members of inorganic bean producer were higher than the organic bean producer. Average farm size of organic bean producer was higher than the inorganic bean producer. Organic bean producer got more training than the inorganic bean producer. Inorganic bean producer contacts more with the extension worker than the organic bean producer. Inorganic bean producer had more years of farming experience than the organic bean producer. Organic bean producer had more organizational participation than the inorganic bean producer. Organic bean producer had agricultural Apps in their mobile phone but no inorganic bean producer had agricultural Apps in their mobile phone. Inorganic bean producer used more hybrid seed in their farm than the organic bean producer. Organic bean producer spent more time with their neighbouring farmers than the inorganic bean producer.

The study also identified the major factors affecting the gross margin of bean farming in the research area. This research showed that inorganic bean producer got 22.9% higher gross margin in compare to organic bean growers. Moreover, household size had significant impact on gross margin of inorganic bean farmers. If household size increased then gross margin of inorganic bean farming increased by 2.5%. The organizational participation had significant impact on the gross margin of organic bean growers. If organic bean producer organizational participation increased 1% then gross margin increased by 14.8%. This study also identified the factors responsible to adopt organic bean farming in the research area. If farmers age increased 1%, then the probability of adoption of organic bean farming increased by 5.3%. The coefficient of organizational participation had significant impact to adopt organic bean farming. If farmers organizational participation increase, then the probability of adoption of organic bean farming increase by 8.3%.

CONCLUSION AND POLICY RECOMMENDATIONS

This study examines the factors influencing adoption and the relative profitability of organic versus inorganic country bean farming in Narsingdi district, Bangladesh. This study found that organic and inorganic bean farmers were almost similar age, with both groups being middle-aged. Organic farmers had slightly less farming experience compared to their inorganic counterparts. A notable difference was observed in organizational involvement, with nearly all organic farmers participating in different organization, while just over half of inorganic farmers did so. The result reveal that inorganic bean farmers achieve a 22.9% higher gross margin compared to organic farmers, indicating greater short-term profitability for conventional methods. However, household size and organizational participation significantly influence gross margins, with larger households benefiting more from inorganic farming, while organizational involvement enhances organic farming profitability. The adoption of organic practices by farmers is significantly influenced by key factors including bean yield, the age of the farmer, their farming experience, and involvement in the organizations. Younger farmers and those with organizational ties are more inclined toward organic farming, whereas higher yields and extensive farming experience favour inorganic methods.

The study reveals that farmers' involvement in agricultural organizations significantly influences their decision to adopt organic bean farming practices. Building on this finding, development agencies and government agricultural departments should implement structured intervention programs to further encourage this transition. To advance sustainable agriculture, policymakers must implement measures that narrow the economic disparity between organic and conventional farming systems. This can be achieved through targeted financial incentives, enhanced technical assistance, and improved market linkages for organic producers. Strengthening farmer cooperatives and expanding skill-building initiatives would further motivate the transition to organic methods. Concurrently, educational campaigns should emphasize the ecological advantages and public health benefits of organic cultivation to reshape agricultural decision-making. Further studies are needed to develop yield-boosting techniques and cost-efficient production methods for organic crops, making them more viable alternatives. Through these comprehensive efforts, Bangladesh can simultaneously fulfil increasing consumer demand for organic produce, safeguard agricultural incomes, and protect environmental resources for future generations.

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Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

Ethical approval

For this type of research formal consent is not required

Authorship

Akther H: Conceptualization, methodology, investigation, data collection, writing the original draft and review and editing.

Hasan MR: Supervision, conceptualization, methodology, investigation, writing the original draft and review and editing.

Anny SA: Supervision, review and editing.

Islam MA: Conceptualization, methodology, formal analysis, review and editing.

All Authors are agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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