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Determinant Factors of Farmers' Performance Regarding Fertilizer Application: An Overview from Bangladesh

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Authors' contributions

This study was carried out in collaboration among all authors. Author TB designed the study, organized data collection, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MKU contributed to manage research flow and facilitate data collection. Authors SH and NHK managed the analyses and interpretation of the study. Author MZR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Farmers of Bangladesh use a less amount of urea fertilizer compared to the nutrient requirement and soil fertility status. Hence, a significant gap between actual and recommended doses of fertilizers used by farmers have been reported in many instances. Therefore, this study assessed farmers' performance towards fertilizer application, and explored the contribution of selected characteristics on that performance.

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Study Design: This study employed a cross-sectional survey method using a correlational and descriptive research design.

Place and Duration of the Study: The study was conducted in twenty-one villages of Gaibandha district in Bangladesh during 17 July, 2017 to 20 September, 2017.

Methodology: A total of 355 farmers were selected as sample using multistage random sampling. Data, collected using structured questionnaire, were subjected to descriptive analysis, Pearson correlation and multiple linear regression for describing the level of selected variables, their relationships and their contributions on farmers' performance, respectively.

Results: Most (45.9%) of the farmers had high level of performance regarding fertilizer application. Farmers' age, household size, educational level, farm size, training received, extension media contact, knowledge and attitudes of farmers had positive and significant relationship with their fertilizer application performance. Regression model explained 45.3% of variance of farmers' performance where age, household size, farm size, training received, extension media contact, knowledge and attitudes of farmers were found significant predictors of farmers' fertilizer application performance. Knowledge was found to be the most contributing factor followed by age and training received.

Conclusion: The study concludes with recommendations that are expected to improving fertilizers application scenario of Bangladesh.

Keywords: Fertilizer application; rice; farmers' performance; knowledge; attitudes.

1. INTRODUCTION

In the crop sector, rice is a dominant crop occupying about 75% of the total cropped area of Bangladesh [1]. Rice plays a vital role in contributing one-half of the agricultural GDP and one-sixth of the national average income in Bangladesh contributed by rice sector [2]. Despite having a suitable agro-climatic conditions to grow rice round the year, the national average rice yield of Bangladesh is much lower (2.94 t/ha) than that of other top rice-growing countries [3]. Moreover, about 27.26 million tons of rice will require to feed its up growing population for the year 2020 [4]. Hence, there is a need to increase yield of rice from the present 2.74 to 3.74t/ ha [5]. Nevertheless, rice yield growth has slowed considerably in recent years and has failed to keep up with population growth [6]. Besides, unbalanced use of fertilizers is one of the main reasons that has favored the emergence of nutrient deficiency in Bangladesh soils [7]. Intensification of agricultural land use without proper replenishment of plant nutrients has caused depletion of fertility especially in the smallholder farms [8].

In Bangladesh, farmers were found to apply a less amount of urea fertilizer compared to nutrient requirements and soil fertility doses [9]. Furthermore, the rates and times of applying nitrogenous fertilizer by farmers was not well matched to the needs of the crop for supplemental N [10]. Moreover, majority of farmers rarely apply fertilizer according to the recommendation from concern organizations

such as Soil Resource Development Institute (SRDI) and Dept. of Agriculture Extension (DAE). Yield gap between research stations and farmers' fields is therefore effectively minimized through farmers' performance improvement in balanced fertilizer management [11].

A number of studies have been performed on farmers' fertilizer management in Bangladesh focused on impact of excessive use of fertilizer [12,13]. On the contrary, other studies reported farmers' less use of fertilizers compare to their recommended doses due to resources constraints [14,8]. Rural farmers are less knowledgeable about the importance of applying recommended doses of fertilizer for better production. A wide range of factors including farmers' demographical, psychological and economical characteristics influence farmers' performance behavior in applying agricultural practices [15] however so far no research was reported in the context of Bangladesh. This study was therefore designed to study farmers' fertilizer application performance. Furthermore, it identifies the factors and their contribution to farmers' application performance in rice cultivation. The objectives of this study are as follows:

- i. To determine the level of farmers' performance towards fertilizer application;
- ii. To assess the selected characteristics (age, educational level, household size, farm size, annual income, extension media contact, training received, knowledge and

- attitudes) of the farmers towards fertilizer application;
- iii. To investigate the relationship among the selected characteristics of the farmers with their performance towards fertilizer application;
 - iv. To explore the contributions of the selected characteristics of the farmers on their performance towards fertilizer application;

1.1 Related Review of Literature

Several factors such as farmers' attitudes, knowledge and support services might affect their farming performance [16]. Likewise, farmers' knowledge on Soil Testing and Fertilizer Recommendation Facilities (STFRF) was reported to be a significant determinants of farming performance [14]. Farmers' knowledge of soil management plays an important role in developing more sustainable farming systems [17]. In the context of fertilizer, farmers' local knowledge about soil fertility and management strategies play a vital role [18]. To understand farmers' perceptions and attitudes regarding technology is crucial for interpreting the implementation behavior of the farmers [19]. According to Jia et al. [20] knowledge received from training can reduce farmers' N fertilizer use. For any technological and management interventions, users' knowledge and attitude were found to be critical [21]. According to Oluwatusin and Shittu [22], the main determinants of yam production performance were age and educational level of the farmers which had positive coefficients as well as statistically significant. Household size has positive relation with adoption of improved technology of soil fertility [23].

Farmers' knowledge and attitudes regarding Tailor-made fertilizers (TMF) technology is important for interpreting farmers' behavior towards enhancement technologies of fertility management [19]. Similarly, Wei and Chu [24] performed a survey on individuals in the service industry and found that attitude towards work had a positive relation on performance. Studies showed that a number of characteristics of individual affect the quality and quantity of his farming performance [25]. Elsewhere, it was reported that farmers' socioeconomic factors along with their knowledge on the subject matter affect their of soil fertility management [26].

Measurement of farmers' performance in farming practices has already been gained attention in academic research such as Sayang [27]

analyzed work performance of paddy farmers in Gambia; Hassan [28] studied paddy farmers' personality traits in Malaysia, whereas Nkari et al. [29] determined commercial farmers' performance in Kiambu County, Kenya. However, research is very rare to study the extent of farmers' performance regarding fertilizer application and what psychological and socio-economic factors are in fact influence that performance. Identifying factors that upgrade farmers' performance towards fertilizer application will open new scope for researchers and policy maker to develop strategies regarding good fertilizer management practices.

2. MATERIALS AND METHODS

A cross-sectional survey method was used to administer this research. In order to collect relevant data for a pre-determined sample a structured interview schedule was carefully prepared included both open and closed form questions.

2.1 Location, Population and Sample

To identify the study location and determine the study sample, a multi-stage sampling procedure was adopted [30]. First, Gaibandha one of the major rice growing districts of Bangladesh was purposively selected. Second, three (3) upazilas (Sub-district) namely Gobindho Gonj, Polash Bari and Shadulla Pur out of five (5) upazillas (Sub-district) of Gaibandha district were chosen randomly. Third, seven (7) villages from each upazila were randomly selected. Thus, a total of twenty one (21) villages were constituted the locale of this study. All the rice farmers from the identified villages was comprised the population of the study which constituted a total of 3762, 355 farmers. Based on Krejcie-Morgan [31] Table, 355 farmers were represented as the study sample. Respondents were selected from each village using proportionate random sampling technique.

2.2 Validity and Reliability Analysis

To ensure the content validity, initial pool of items for interview schedule were sent to a group of experts from representing different universities. Based on their responses, the questionnaire was finalized and sent to 20 non-sampled rice farmers who were randomly selected for pre-testing. Cronbach's Alpha test is utilized to measure the items under each construct in the questionnaire. In the current study, the

Cronbach's for the statements of work performance, knowledge and attitudes was 0.862, 0.830, and 0.770, respectively. According to rule of thumb given by the researcher [32], if Cronbach's Alpha value is > 0.9 means Excellent, >0.8 means Good, >0.7 means Acceptable > 0.6 means Questionable, >0.5 means poor, and <0.5 means Unacceptable. Based on rule of thumb, the Cronbach's Alpha values of the items were found reliable.

2.3 Measurement of Dependent Variable

The dependent variables of the study was farmers' work performance towards fertilizer application. Fourteen (14) statements related to fertilizer application in rice were employed for judging the work performance of farmers. The Likert scale is highly applicable technique to measure work performance [27]. For this research, the researcher employed five points Likert scale [33] and farmers were requested to specify their degree of agreement and disagreement against fourteen (14) statements. The scores were assigned as 5 for strongly agree, 4 for agree, 3 for not sure, for disagree and 1 for strongly disagree. Shah [34] employed similar technique to measure the work performance among potential paddy farmers in Malaysian granary areas.

2.4 Data Collection and Statistical Analysis

Data were collected from respondent farmers in face-to-face setting during July to September, 2017. Statistical Package for Social Science (SPSS) v_23 was employed for analyzing data. To achieve the objectives of the study, descriptive statistics including frequency count, percentage, mean and standard deviation was computed. Data were classified in to different groups for better understanding and interpretation of the phenomenon of interest. Besides, Pearson correlation and multiple regression with 0.05 and 0.01 level of probabilities were performed for exploring the inter-relationship and determining the contribution of the selected characteristics of farmers to their performance towards fertilizer application respectively. The multiple regression works with the following formula:

$$Y = b_0 + b_1 x_1 + b_2 x_2 + \dots + b_k x_k + e \quad (1)$$

Here, Y is the probability of farmers' performance as the dependent variable, X1, X2 Xk indicate the independent variables such as age,

educational level, household size, farm size, annual income, extension media contact, training received etc., while b1, b2... bk are the regression coefficients of independent variables and b0 is the constant.

3. RESULTS AND DISCUSSION

This section is organized as follows. First sub-section deals with farmers' selected characteristics. Second sub-section discusses farmers' performance towards fertilizer application while third and last sub-sections describe interrelationships and contribution of farmers' selected characteristics towards their performance.

3.1 Level of Selected Characteristics of Farmers

Table 1 depicts farmers' selected characteristics. It showed that the highest percent (25.9%) of the respondents fall in to 41-50 years of age category while the lowest portion (12.1%) of them belonged in the group of up to 30 years. Age is recognized as an important factor to adopt any technology including fertilizer application by several researchers. Majority (62.5%) of the respondents had small house hold size consisting of 4 to 6 members whereas the lowest percentage (9%) of respondents had large household size having 10 or more family members. Due to the increased awareness among the people about birth control, increased livelihood expenses and increased women involvement with income generating activities, the average household size in Bangladesh is gradually decreasing [35]. A little above one-fourth of the farmers (26.8%) had secondary education and 4.2% of them completed graduation. Concerning annual income, majority (57.7%) of the respondents had less than 100 thousand BDT (1 USD= 84 BDT). The results are consistent with Kabir's [35] findings reported that highest percentage of farmers were illiterate (52.3%) and had annual income (36.9%) of less than 100 thousand BDT. The highest portion (71.3%) of the respondents had marginal farm size having less than 0.6 hectare of land (based on classification of the Ministry of Agriculture, Bangladesh). Regarding training, 47% of farmers didn't received any kind of training while 33.8% and 3.75% of them received short duration and long duration training, respectively. Among the respondents 53% of farmers had participated in various agricultural training programs. Receiving of training

enhances farmers' knowledge on new techniques of handling higher agricultural production. Besides, major portion (50.7%) of respondents had moderate extension media contact. About half of the farmers had moderate level of knowledge (51.8%) and favorable attitudes (52.4%) on fertilizer application. A farmer having adequate knowledge can judge a situation more clearly and understand what technology should apply in his field.

3.2 Level of Performance of Farmers towards Fertilizer Application in Rice Cultivation

Table 2 innumerate farmers' level of performance towards fertilizer application in rice cultivation. The mean (M) and standard deviation score was 3.39 and 0.737 respectively. Highest portion (45.9%) of the respondents experienced a high level of performance, 38.3% considered a moderate level and only 15.8% indicated low level of performance. This findings is supported by Syang [27] who found that highest portion (51%) of paddy farmers had high level of performance in Central River Region in Gambia. However, Nkari et al. [29] found that most of the commercial farmers had low level of performance in Kenya.

3.3 Relationship between Farmers' Selected Characteristics and their Performance towards Fertilizer Application

Table 3 revealed that age, household size, educational level, farm size, training received, extension media contact, knowledge and attitudes of farmers had positive significant relationship with farmers' performance towards fertilizer application at 5% level of significance. This result implies that higher of these eight selected characteristics of farmers will result to higher the level of their performance and vice versa. These findings are consistent with Oluwatusin and Shittu [22] and Mugonola et al. [23]. Julius et al. [36] mentioned farm size of farmers was positive and significantly related with the farmers' output in Nigeria. Factors like extension contact and training of farmers showed significant positive relation with ISFM adoption [37]. As attitudes had a positive relationship with performance, which means better work attitude leads to better performance [24]. In addition, knowledge and individuals' performance significantly related [38].

Despite farmers' annual income seems to be an important determinant of their purchase of input like fertilizer [39], as like as Bremmer et al. [40], this study did not find any significant relationship between farmers' annual income and their performance regarding fertilizer application. This signifies that farmers' performance towards optimal application of fertilizer do not vary due to their economic status rather it might associate with other factors like knowledge or attitudes on fertilizer application practices.

3.4 Estimation of Identifying the Contributing Factors on Farmers' Performance towards Fertilizer Application

Table 4 shows the multiple regression coefficients (R) value is .701, which indicates that there is high deal of variance exist in between the selected characteristics of farmers and their performance. R² value is .479 indicates 45.3% of the variance of farmers' performance is explained by the selected characteristics of farmers in the model. The F-ratio (37.129) was significant at 1% implying goodness of fit of the model.

As depicted in Table 4, seven characteristics of farmers i.e., age (P = .000), household size (P = .005), farm size (P = .046), training received (P = .000), extension media contact (P = .000), knowledge (P = .000) and attitudes (P = .011) towards fertilize application are statistically significant predictors in explaining performance of farmers. On the other hand, annual income (P = .793) and educational level (P = .052) of farmers appear as statistically not significant to the variation of farmers' performance.

Y (Farmers' performance) =

$$-.102 + .009 X_1 + .047 X_2 + .000 X_3 + .013 X_4 + .165 X_5 + .020 X_6 + .146 X_7 + .507 X_8 + .121 X_9 + e$$

The equation shows the probability of farmers' performance towards fertilize application. The summarized findings of the model explain 47.9% of the variance of the performance of farmers towards fertilize application. Hence, it can be said that the regression model fit the data and explanatory power of the model is significant. This finding is in line with Shah [34] who stated that coefficients farmers' performance model explained 44% variation on farmers' performance in rice cultivation in Malaysia.

Table 1. Distribution of farmers according to their socio-economic characteristics

Variables	Level	Frequency	%	Mean	SD
Age (Years)	≤30	43	12.1	48.12	13.62
	31-40	72	20.3		
	41-50	92	25.9		
	51-60	83	23.4		
	>60	65	18.3		
Household size (No. of persons)	Very small (1-3)	58	16.3	5.27	1.76
	Small (4-6)	222	62.5		
	Medium (7-9)	66	18.6		
	Large (≥10)	9	2.5		
Educational level (Yrs. of schooling)	Illiterate (0)	143	40.3	5.09	4.63
	Primary (1-5)	79	22.3		
	Secondary (6-10)	95	26.8		
	Higher secondary (11-12)	23	6.5		
	Graduation (≥13)	15	4.2		
Annual income (‘000’ BDT)	>100	205	57.7	106.04	76.02
	100-150	73	20.6		
	>150-200	34	9.6		
	>200-250	21	5.9		
	>250	22	6.2		
Farm size (Hectare)	Marginal (<0.6 ha.)	253	71.3	0.50	0.38
	Small (0.6-<1 ha.)	73	20.6		
	Medium (1-<3 ha.)	26	7.3		
	Large (≥3 ha.)	3	.8		
Extension media contact (Score)	Low (≤2.33)	142	40.0	2.45	0.72
	Moderate (2.34-3.66)	180	50.7		
	High (≥ 3.67)	33	9.3		
Training received (No. of days)	No training (0 days)	167	47.0	5.09	6.35
	Short duration (1-10 days)	120	33.8		
	Medium duration (11-20 days)	55	15.5		
	Long duration (>20 days)	13	3.7		
Knowledge on fertilizer application (Score)	Low (≤2.33)	42	11.8	3.34	0.70
	Moderate (2.34-3.66)	184	51.8		
	High (≥ 3.67)	129	36.3		
Attitude towards fertilizer application (Score)	Highly Unfavorable (≤2.00)	31	8.7	3.13	0.63
	Unfavorable (2.01-3.00)	117	33.0		
	Favorable (3.01-4.00)	186	52.4		
	Highly Favorable (≥4.01)	21	5.9		

Table 2. Distribution of farmers according to their performance towards fertilizer application

Level	Frequency	%	Mean	SD
Low (≤2.33)	56	15.8	3.29	0.74
Moderate (2.34-3.66)	136	38.3		
High (≥ 3.67)	163	45.9		

Table 3. Relationships among the selected characteristics of the farmers with their performance towards fertilizer application

Dependent variable	Independent variables	Pearson correlation coefficient (r) value with 353 d.f.	Tabulated value of 'r'	
			0.05 level	0.01 level
Farmers' Performance towards fertilizer application	Age	.350**	.105	.137
	Household size	.227**		
	Educational level	.106*		
	Annual Income	.034		
	Farm size	.248**		
	Extension media contact	.255**		
	Training received	.202**		
	Knowledge on fertilizer application	.571**		
	Attitude towards fertilizer application	.291**		

*Significant at 0.05 level of probability, and **Significant at 0.01 level of probability

Table 4 indicates that knowledge makes the highest contribution ($\beta = .479$) to explain farmers' performance on fertilizer application. It implies that the higher the knowledge the higher the performance. The knowledgeable persons are more capable of making consent decision based on the trade-off between benefit and cost of every action. Therefore, they drive towards agricultural management practices (e.g. fertilizer application) that give them the highest performance.

Age ($\beta = .174$) is the second most contributor on farmers' performance followed by training received ($\beta = .172$), extension media contact ($\beta = .143$), household size ($\beta = .113$), attitudes ($\beta = .104$) and farm size ($\beta = .086$) of farmers, respectively. This result indicates that aged farmers are generally experienced at farming practices (e.g. fertilizer application) which improve their performance. Besides, training and extension media contact facilitate learning and knowledge acquisition. Therefore, the likelihood of adopting improve agricultural technologies are expected to be higher to those farmers categories. Labor availability is one of the other reasons that influences decision of improved farming practices. Therefore, farmers with a larger household size have to be depend more on family labor. Farmers' favorable attitude also influence their farm management decisions which improve their performance. In addition, farmers with large farm size are keen to maximize their return; therefore, their performance towards fertilizer application are more rational. Hence, it was found that farmers

who had one or more of these characteristics at the higher level, had the higher level of performance towards fertilizer application and it also encourage to farmers to apply fertilizer in rice cultivation.

This results showed the positive contribution of selected socio-economic and psychological characteristics of farmers to their performance towards fertilizer application. Previous research also support this findings such as Knowledge has a positive influence on individual work performance [41]. Bekele et al. [42] explained that individuals' work performance is significantly influenced by their attitudes. Oluwatusin and Shittu [33] found that yam production in Nigeria was positively influenced by age of the farmers. Training also had an influence on competency level of the farmers so that an individual can apply the acquired knowledge and skills from the training [43]. Farouque et al. [44] identified farm size and media contact of farmers as significant predictors producing positive regression coefficients on the perception to use integrated soil fertility and nutrient management for crop production in Bangladesh. Besides, Jackline et al. [45] provided supportive results that training and household size of farmers had been found to influence the decision to adopt improved technologies of soil fertility in Uganda.

Annual income and educational level are expected to be important predictors for fertilizer application, yet they were found to be statistically non-significant to farmers' performance regarding fertilizer application in this study.

Table 4. Linear multiple regression model showing coefficients of performance of farmers with the contributing characteristics

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.102	.213		-.481	.631
(X1) Age	.009	.002	.174	4.207	.000
(X2) Household size	.047	.017	.113	2.839	.005
(X3) Educational level	.013	.007	.081	1.954	.052
(X4) Annual Income	.000	.000	.011	.262	.793
(X5) Farm size	.165	.083	.086	2.003	.046
(X6) Extension media contact	.146	.041	.143	3.586	.000
(X7) Training received	.020	.005	.172	4.398	.000
(X8) Knowledge on fertilizer application	.507	.043	.479	11.821	.000
(X9) Attitude towards fertilizer application	.121	.047	.104	2.571	.011

$R = .701$; $R^2 = .492$; Adjusted $R^2 = .479$; Std. Error of the Estimate = .532;
 $F = 37.129$; Sig. = 0.000

Similar trend is found from the study on performance of Agro-tourism farms in South Africa by Barbieri and Mshenga [46] who established that characteristics like entrepreneur's education level were found not to have a significant impact on performance of these farms. Debashish et al. [47] supported that annual family income of the farmers was not significant on problem faced by them during training in Bangladesh.

From the overall discussion it is clear that selected characteristics of farmers influenced their ability to achieve superior performance.

4. CONCLUSION

Farmers' high level of performance is very essential for improving rice production through effective and efficient fertilizer application. The results revealed that the major portion (45.9%) of the farmers had high level of performance regarding fertilizer application in rice that proved an opportunity for better production and a possible room for improvement. The finding indicated that, age, household size, educational level, farm size, training received, extension media contact, knowledge and attitudes of farmers had positive and significant relationship with their performance regarding fertilizer application. Therefore, these characteristics should be given greater attention in improving farmers' farming performance. Moreover, age, household size, farm size, training received, extension media contact, knowledge and attitudes of farmers were statistically significant as predictors in explaining performance of farmers. Hence, these selected characteristics of farmers are crucial to clarify the performance of farmers in applying fertilizer in rice cultivation. Knowledge is highlighted as most contributing factor on farmers' performance. Therefore, should give more emphasis to improve knowledge level of farmers to achieve superior performance towards fertilizer application. Farmers' estimate coefficients performance model explained 45.3% of the variance in farmers' performance. This study provides practical evidence on contributions of selected characteristics of farmers to their performance as well as knowledge that could motivate farmers in applying fertilizer effectively and efficiently to improve rice production in Bangladesh.

Adopting suitable agricultural policies and strategies might enhance farmers' performance

towards fertilizer application. Therefore, the ministry of agriculture of Bangladesh should take steps to impart fertilizer related training to farmers. Moreover, Department of Agriculture Extension (DAE), Bangladesh should arrange effective extension services to enhance farmers' performance by providing updated knowledge related to fertilizer application in rice.

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COMPETING INTERESTS

Authors have declared that no competing interests exist. All authors have approved the Manuscript and agree for its submission to Asian Journal of Agricultural Extension, Economics & Sociology.

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