



Impact of Herbicide Application in Rice Cultivation: A Case Study in Mymensingh District of Bangladesh

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Abstract: The research has been conducted to determine the impacts of herbicide application on rice cultivation and to explore the contributory factors affecting herbicide application in rice cultivation. Characteristics of the rice grower farmers were age, education, rice farming area, family agricultural labor, rice farming experience, annual rice farming income, organizational participation, extension contact, knowledge on herbicide use, attitude towards use of herbicide, time spent in rice cultivation. Data were collected from randomly selected 323 Common Interest Group (CIG) member rice farmers of three selected unions (Dhara, Phulpur, Nandail) of three selected upazillas (Haluaghat, Phulpur, Nandail) of Mymensingh district of Bangladesh with the help of a pre-tested interview schedule during the period from 01 January 2024 to 30 March 2024. It was revealed through t-test that there was positive and significant impact of using herbicide in cost, frequency of application, time and yield aspect. Multiple regression analysis indicated that attitude of the farmers towards herbicide was most important characteristic which strongly influenced the impact of herbicide application in rice cultivation. Age, education, rice farming area and extension contact of the farmers also had remarkable influence on the impact of herbicide application in rice cultivation. The findings may helpful for the policy makers to increase the production of rice through application of herbicides.

Key Words: Herbicides; Rice cultivation; Impact; Multiple regression.

INTRODUCTION

Herbicide, an agent, usually chemical, for killing or inhibiting the growth of unwanted plants, such as residential or agricultural weeds and invasive species. A great advantage of chemical herbicides over mechanical weed control is the ease of application. Most herbicides are considered nontoxic to animals and humans, but have the ability to cause substantial mortality of nontarget plants and the insects that depend on them, especially when applied aerially (Ahmed *et al.*, 2005).

According to Singh *et al.* (2014) weeds are regarded as most disdain to crop production and account for about one third of total losses caused by all the pests. The high nutrient and water requirements along with less competitive nature of high yielding dwarf varieties have provided the favourable environment for increased weed infestation.

Approximately 28% to 80% yield is reduced due to weed infestation in transplanted rice (Patel *et al.*, 2023).

Weed management is the most labor-intensive work in the rice production and increasing labor wages make the rice cultivation less profitable. The prevailing weed control was done manually hand weeded which is also time consuming and expensive and cannot be done on time due to various reasons (Ahmed *et al.*, 2005). Mechanical weeding and use of herbicides are the alternative way of hand weeding. Japanese rice weeder and BRRJ weeder are use in some areas of the country. But due to some disadvantages it has not gained widespread popularity. Besides this, there are some alternative options like use of herbicide are now became popular in some areas of Bangladesh. These herbicides are effective in controlling weeds alone or in combination with hand weeding (Ahmed *et al.*, 2005). In recent years, chemical weed control (*viz.*,

herbicide application) has increased in Bangladesh (BRRI *et al.*, 2022). In Bangladesh the annual consumption of herbicides grew over 5700 metric tons in 2017 (BCPA, 2018) compared to only 108 tons during 1986-87 (BBS, 2015), and the growth is almost exponential. In recent year 2023 herbicide consumption in Bangladesh 8085 metric tons and in 2024 herbicide consumption in Bangladesh 8120 metric tons (BCPA, 2025). Herbicide use increasing rate 0.43%. It is good singe for herbicide use in Bangladesh for rice cultivation.

Farmers are compelled to herbicide due to scarcity and higher price of labor. Moreover, this is an economical and effective approach to weed control. Weed control with herbicides remains five times cheaper than manual weeding in areas where labor scarcity and high wages are serious problems (Rao *et al.*, 2007). Weed management practices can be grouped into three broad categories namely cultural and preventive; physical or mechanical; and chemical weed control. Chemical weed control is preferred because of its better efficiency along with less cost and time involvement as well as no mechanical damage to crop. Effective weed control depends on the proper selection of herbicides depending on the type of weed flora infesting the crop and further herbicide should be applied at optimum dose and time using proper application technology (Singh *et al.*, 2014).

Food safety and herbicides have become serious human concern and synthetic herbicides are an environmental contaminant. Despite the harmful effects of synthetic herbicides to human health, environment other living beings, we cannot replace the chemical herbicides by manual techniques, IPM and organic agriculture overnight. Farmer's skill development training on the judicious use of herbicides and rice harvest time after spray of herbicides are one option to reduce health risks from harmful herbicides. However, very few researches explored farmers' actual practices, while applying an approach based on practice theory could improve understanding of these practices and the changes therein.

Therefore, it is urgent to formulate national policy to reduce health risk to produce safe food by ensuring judicious use of herbicides. Reliable statistical data are meager to indicate the magnitude of impact of herbicides in Bangladesh. However, there are some unreliable evidences and inadequate reports on impact of herbicides in Bangladesh. Hence, a systematic research was needed to find out impact of herbicides application in rice cultivation.

Bangladesh, an agricultural country and in order to enhance crop production, farmers have expanded the use of herbicides and fertilizers to meet the government's food sufficiency targets. Nowadays, farmers fully rely on herbicides for increasing rice cultivation and protecting plantations from different weeds and diseases. Developing countries account for only 20% of herbicide use at the global level; however, their casualty rates are very high due to herbicide poisoning (Kesavachandran *et al.*, 2009). In developed countries, many studies have assessed farmers' levels of knowledge of safe herbicide usage; however, very few specific studies on this subject have been conducted.

Therefore, the present study was undertaken will the following specific objectives to i) ascertain the impact of herbicide application in rice cultivation, ii) describe socio-economic profile of the rice growers and iii) explore the contributory factors affecting herbicide application in rice cultivation.

MATERIALS AND METHODS

LOCALE OF THE STUDY

Department of Agricultural Extension (DAE) formed Common Interest Group (CIG) intervention areas for rice farming were considered purposively for selecting the locale of the study. Thus, Haluaghat, Phulpur and Nandail upazilas under Mymensingh district were selected purposively as the case study where renowned herbicides companies were selling their herbicides to the farmers and farmers were using those for controlling rice weeds. Three (3) CIG intervention unions, namely Dhara, Phulpur and Nandail were then selected randomly by taking one (1) from each selected upazila as the locale of the study. Each union contain two village namely Dhara (Kutikura and Chasri), Phulpur (Bashtola and Nagua) and Nandail (Saber and Dataratia) as the locale of the study.

POPULATION AND SAMPLE OF THE STUDY

Bless and Higson-Smith (1995) defined the target population as a set of elements that the researcher focuses upon and which the results obtained by testing the sample should be generalized. Allison *et al.* (1996) described a population as the larger collection of all the subjects that one wishes to apply one's conclusion. The target population for this study was concerned with the CIG farmers of the Department of Agricultural Extension (DAE) being engaged in rice farming by using herbicides. A total of 3490 rice CIG farmers in the selected three unions of the selected three upazilas named Haluaghat, Phulpur and Nandail of Mymensingh district were actively producing rice by using traditional herbicide as a member of CIG under DAE. These 3490 rice CIG farmers were considered as the population of the study.

The sample size was determined by using following formula developed by Yamane (1967):

$$n = \frac{N}{1 + e^2}$$

Where,

n = sample size

N = population size

e = the level of precision (5%)

By putting the values in the above formula, the sample size was determined as 323.

DATA COLLECTION PROCEDURE

Data were collected by the researcher himself through face-to-face interviewing from the selected sample farmers by using Bengali interview schedule. The data were collected during the period from 01 January, 2024 to 30 March, 2024. Researcher has visited every selected sample

respondent with the help of the Sub-Assistant Agricultural Officer (SAAO) of the respective block with prior appointment. In case of non-availability of the sample farmers, the researcher paid make-up visit to their convenient date and time. However, it was not possible to collect data from seven (7) farmers in the original sample due to their unavailability at the time of interview despite several attempts to contact them. Therefore, the researcher had to collect data from seven (7) farmers from the reserve list.

MEASUREMENTS OF INDEPENDENT VARIABLES OF THE STUDY

Eleven (11) characteristics of the rice grower farmers were selected after thorough searching of literatures and discussions with the Advisory Committee Members and relevant experts as the independent variables of the study. Brief measuring procedure of these variables have been given in Table 1.

Table 1. List of independent variables with their measurement procedures

Variables	Measuring Procedures (Score)
1. Age	One (1) score for one (1) year of age
2. Education	One (1) score for one (1) year of successful schooling, Zero (0) for illiterate and 0.5 for can sign only
3. Rice farming area	One (1) score for one (1) hectare of rice farming area
4. Family agricultural labour	One (1) and half (0.5) Score for adult (≥ 18 years) and adolescent (≥14 to <18 years) respectively who engaged in agricultural rice farming
5. Rice farming Experience	One (1) score for one year of rice farming experience
6. Annual rice farming income	One (1) score for 1000 Bangladeshi Taka (BDT.) annual income from rice farming
7. Organizational Participation	Scores of 3, 2, 1, and 0 for participation as Executive Officer, Executive Committee Member, Ordinary Member and no participation respectively for each of three (3) selected organizations
8. Extension contact	Scores of 3, 2, 1, and 0 for regular, occasional, rare and not at all contact respectively with each of 17 selected extension media
9. Knowledge on herbicides use	Two (2) score for each of 14 selected questions on rice farming
10. Attitude towards use of herbicides	Scores of 4, 3, 2, 1, and 0 for strongly agree, agree, no opinion, disagree and strongly disagree respectively for positive statements and reverse scores for negative statements for each of 12 attitudinal statements towards use of herbicides
11. Time spent in rice cultivation	Score 1 for 1 hour spending in a day for rice cultivation

MEASUREMENTS OF DEPENDENT VARIABLES OF THE STUDY

Impact of herbicide application in rice cultivation is the dependent variable of the study. It was measured based on four (4) issues regarding herbicide impact such as cost, frequency, time and yield. A comparison between herbicide user and non-user was made based on these four parameters (Table 2). Finally, overall impact was calculated through making unit free from the above four issues and calculate by average. The independent sample t-test was done for checking impact.

Table 2. Comparison between herbicide user and non user.

	Herbicide use				t	P Value & Sig.
	Herbicide Use		Herbicide Not Use			
	Mean	SD	Mean	SD		
Cost	655.31	348.01	4583.61	641.92	46.240	0.001**
Time	3.74	1.02	17.43	1.85	55.885	0.001**
Frequency	3.13	1.23	4.20	0.57	10.089	0.001**
Production	6.10	0.47	5.05	0.73	10.779	0.001**

OVERALL IMPACT OF DEPENDENT VARIABLES OF THE STUDY

Overall, the analysis shows that herbicide use significantly improves farm performance by reducing weeding costs, labor, time, and weeding frequency, while enhancing yield productivity. These benefits make herbicides a valuable tool in modern agricultural production systems (Table 3). However, excessive or improper use can lead to environmental and health concerns, including herbicide resistance, soil contamination, and biodiversity loss.

Table 3. Overall impact of dependent variable

Item	Herbicide use				t	P
	Herbicide User		Herbicide Non User			
	Mean	SD	Mean	SD		
Overall Impact	0.618	0.074	0.329	0.059	32.799	0.001*

RESULTS AND DISCUSSION

Salient features of selected characteristics of the rice grower farmers

Eleven (11) characteristics of the farmers were considered as the independent variables of the study which might have contribution on the impact of herbicide application in rice cultivation. Measuring procedures of these variables are discussed in the methodology section.

Salient features like possible range, observed range, mean and standard deviation of these characteristics are presented in Table 4.

Table 4. Salient features of the selected characteristics of the farmers

Characteristics	Possible range	Observed range	Mean	SD
1. Age	Unknown	21-90	48.15	11.79
2. Education	Unknown	0-18.00	6.16	4.53
3. Rice farming area	Unknown	0.1-4.14	0.60	0.53
4. Family agricultural labour	Unknown	1-4	2.54	0.67
5. Rice farming experience	Unknown	5-70	28.23	11.75
6. Annual rice farming income	Unknown	23.6-1155	163.15	136.80
7. Organizational Participation	0-9	0-7	2.00	1.22
8. Extension contact	0-51	9-39	22.06	5.95
9. Knowledge on herbicides use	0-28	8-28	18.40	6.66
10. Attitude towards use of herbicides	0-48	13-32	24.44	4.63
11. Time spent in rice cultivation	Unknown	2-10	5.33	1.59

IMPACT OF CONTRIBUTORY FACTORS THAT IMPACT ON HERBICIDE APPLICATION IN RICE CULTIVATION

To find the contribution of the 11 selected characteristics of the rice grower farmers (independent variables: X) to their impact of the herbicide application in rice cultivation (dependent variable: Y), full model regression analysis was run. The results of full model regression analyses are presented in Table 5.

Table 5. Results of full model regression showing the contribution of the selected characteristics of the farmers to their impact in using herbicides

Selected characteristics of the farmers	Coefficients				Sig.	Collinearity Statistics	
	Unstandardized Coefficients		Standardized Coefficients	t		Tolerance	VIF
	B	SE					
(Constant)	.313	.030		10.374	.000		
Age (X ₁)	.001	.000	.119	2.370	.019*	.775	1.291
Education (X ₂)	.002	.001	.115	2.036	.043*	.620	1.614
Area (X ₃)	.016	.007	.125	2.393	.017*	.726	1.377
Family labor (X ₄)	-.001	.005	-.009	-.188	.851	.899	1.113
Organization Participation (X ₇)	.002	.002	.054	1.003	.317	.685	1.460

Extension contact (X ₈)	.001	.001	.104	1.973	.050*	.709	1.411
Knowledge (X ₉)	.000	.001	.016	.273	.785	.601	1.664
Attitude (X ₁₀)	.009	.001	.547	11.212	.000**	.828	1.208
Time (X ₁₁)	.001	.002	.019	.388	.698	.803	1.245

*Significant at 0.05 Level, **Significant at 0.01 Level
 R = 0.710, R Square = 0.504, Adjusted R Square = 0.487, F ratio = 28.478 at 0.000 level

It was observed that the full model regression results revealed that out of 11 selected characteristics of the farmers, five (5) characteristics such as age (X₁), education (X₂), farming area (X₃), extension contact (X₈) and attitude towards use of herbicide (X₁₀) had significant contribution to the impact of herbicide application in rice cultivation.

In Collinearity Statistics, it was found that the tolerance of the independent variables were ≥ 0.775 and the Variance Inflation Factor (VIF) of the independent variables were ≤ 1.291 . Miles (2014) suggested that generally, a Tolerance of < 0.25 or VIF of > 4 indicates that multicollinearity might exist, and further investigation is required. When Tolerance is lower than 0.1 or VIF is higher than 10, there is significant multicollinearity that needs to be corrected. James et al. (2013) also reported that VIF of 5 or less is not problematic for collinearity in a multivariable (linear or logistic) model. In the full model regression analysis results, it was found that Tolerance and VIF of all the independent variables were in the acceptable range, i.e., there were acceptable multicollinearity among the independent variables. On these considerations, the results of the full model regression analysis were accepted.

Multiple R, R² and adjusted R² in the regression analysis were 0.710, 0.504 and 0.487 respectively, and the corresponding F-ratio of 28.478 was significant. The regression equation so obtained was as follows:

$$Y = 0.019 (X_1) + 0.043 (X_2) + 0.017 (X_3) + 0.050 (X_8) + 0.000 (X_{10})$$

The standardized regression coefficient of five (5) variables formed the equation and were significant, it might be assumed that whatever contribution was there, it was due to these five (5) variables.

Results of multiple regression analysis again indicated that extension contact (X₈) of the farmers was most important characteristic which strongly influenced the impact of herbicide application in rice cultivation. Age (X₁), education (X₂), farming area (X₃) and attitude towards use of herbicide (X₁₀) of the farmers also had remarkable positive influence on the impact of herbicide application in rice cultivation. On the basis of multiple regression analysis, rice farming experience (X₅) and rice farming income (X₆) show same values. For this reason this two independent variables omit from the analysis table. The rest four (4) variables or characteristics of the farmers had non-significant contribution to the impact in using herbicides. It was inferred that these characteristics had minimum contribution to the impact of herbicide application in rice cultivation. On the basis of regression analysis, contributions of significant five (5) independent variables

to the impact of herbicide application in rice cultivation as the dependent variable are presented below.

Extension contact (X₈): From the results of multiple regression analysis, it was revealed that extension contact on herbicides use of the farmers had strong contribution to the impact of herbicide application in rice cultivation. Extension contact plays an important role in decision making process (Haque et. al., 2016). It is the precursor to the adoption of any innovation. A good extension contacted person could understand the merits and demerits of any technology easily in a short time. Therefore, farmers having high extension contact could easily make them able to efficient in using herbicides for controlling rice weeds. This might be the reason for extension contact having the positive contribution to the impact of herbicide application in rice cultivation.

Age (X₁): Regression analysis indicated that age of the respondent farmers had significant influence on the impact of herbicide application in rice cultivation. Aged farmers have more experience for rice cultivation. Farmers gathered experience in rice farming activities use properly herbicide in exact time for their rice cultivation. This might be the reason for age of respondent farmer play vital role in rice cultivation having the significant influence on impact in using herbicides. Kabir et al., (2023) also found that age is an important factor influence farmer decision for crop processing.

Education (X₂): From the results of multiple regression analysis, it was revealed that educational level of the farmers had contribution to the impact of herbicide application in rice cultivation. Educational level plays an important role in pest removing decision making process (Nasrin et al., 2019). It is the precursor to the adoption of any innovation. An educable person could understand the merits and demerits of any technology easily in a short time. Therefore, farmers having high educational level could easily make them able to efficient in using herbicides for controlling rice weed. This might be the reason for education having the contribution to efficient use of herbicides for controlling rice weeds. Ali *et al.* (2020) revealed that inadequate Protective Behavior of farmers in herbicide use was mainly due to lack of education. Fan *et al.* (2015) found that the Protective Behavior of farmers were affected by their level of education.

Rice farming area (X₃): Regression analysis indicated that rice farming area of the farmers was the important contributor and had significant influence on the impact of herbicide application in rice cultivation. As a result, farmers having more rice farming area might have the capacity to use herbicides efficiently for controlling rice weeds. Kabir and Rainis (2015) found that farm size is an important determinants in pest management decision.

Attitude towards use of herbicides (X₁₀): Regression analysis indicated that attitude towards use of herbicides of the farmers was the important contributor and had significant influence on the impact of herbicide application in rice cultivation. It was very logical that farmers could use efficiently herbicides for rice weed control, if they had favorable attitude towards use of herbicides. Kabir *et al.*

(2017) mentioned that farmers' perception in an important factor to judicial use of herbicides in rice cultivation.

CONCLUSION

Farmers of Bangladesh mostly use herbicides as suggested by the dealers or retailers. However, various factors influence the proper use of herbicide application. Multiple regression analysis indicated that extension contact of the farmers was the most important characteristic which strongly influenced the impact of herbicide application in rice cultivation. Age, education level, rice farming area and attitude towards use of herbicide of farmers also had significant influence on the impact of herbicide application in rice cultivation. Therefore, it may be concluded that agricultural advisory service providing organizations should provide necessary training and motivational campaigning by increase contact with the farmers to increase their knowledge for taking necessary steps and to form favourable attitude towards judicious and efficient use of herbicides for controlling rice weeds.

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Conflict of Interest

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

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