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Assessment of Chemical Fertilizer Use in Mustard Production: Evidence from Kurigram District, Bangladesh

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ABSTRACT

Agricultural practices in the Kurigram district of Bangladesh remain largely traditional, with most farmers relying on plows, ladders, and cattle for crop production and processing. As a result, this district of Bangladesh has been a scene of poverty and persistent food insecurity. This study examines the extent and determinants of chemical fertilizer overuse in mustard cultivation in Nageswari Upazila, Kurigram, Bangladesh. Based on a survey of 250 mustard farmers, the findings reveal that 78.33% applied chemical fertilizers in excess of the recommended doses. Specifically, 95.2% overused Urea, 94.8% TSP, 89.6% MP, 66% Gypsum, and 100% Zinc sulphate—while 24.4% applied Boric acid, which is not officially recommended. The average application per bigha was 36.98 kg for Urea, 34.20 kg for TSP, and 15.57 kg for MP, all significantly exceeding the standard guidelines. Ordinary Least Squares (OLS) regression analysis showed that age, education, farming experience, and agricultural training significantly reduce overuse ($p < 0.01$), while farm size and extension contact were not significant predictors. Additionally, 56.8% of farmers relied on personal experience to determine fertilizer use, with only 9.2% consulting specialists. Multicollinearity tests confirmed the robustness of the regression model. These findings highlight the urgent need for improved farmer education, effective extension services, and local policy enforcement to reduce excessive fertilizer application and mitigate its environmental and economic consequences.

Keywords: Mustard production; Fertilizer utilization; Environmental pollution; Agriculture.

1. Introduction

Bangladesh, a densely populated South Asian country, is experiencing a rapid population increase of approximately 2 million people annually (Karim et al., 2024). If current demographic trends continue, the total population is projected to reach 245 million by the year 2080 (Mondol et al., 2018). As an agrarian economy, agriculture remains a cornerstone of Bangladesh's livelihood, employment, and food security systems. According to the Bangladesh Bureau of Statistics (BBS, 2019), agriculture contributes 13.31% to the national GDP and employs 43% of the workforce, signifying its critical role in rural development and economic stability. Traditionally, farmers in Bangladesh have relied on conventional agricultural practices involving the use of simple tools such as plows, ladders, and draft animals (Akteruzzaman et al., 2012). However, in recent decades, the adoption of modern agro-technologies has gradually increased, leading to improved crop productivity.

Among the important crops grown in Bangladesh, mustard and soybean are the primary oilseed crops, alongside notable production of sesame, flaxseed, peanuts, and sunflower (Gupta & Gupta, 2016). This improvement in oil crop productivity is the result of concerted efforts by farmers, agricultural experts, and extension services. The hard work of farmers, along with technological advancements facilitated by agricultural extension departments, has played a vital role in Bangladesh's agricultural success (Kiron and Islam, 2023). Nevertheless, current agricultural practices often lack sustainability and organization. One of the most pressing concerns is the excessive and indiscriminate use of agrochemicals, particularly chemical fertilizers and pesticides, which has led to declining land productivity and increased vulnerability of soil and water ecosystems (Baweja et al., 2020). The use of agrochemicals in Bangladesh began in the 1960s, primarily as a response to food security challenges. Initially, chemical inputs were applied in moderation and by international guidelines, leading to increased productivity and better land management. However, with rising food demand driven by population growth, the application of chemical inputs increased significantly, often beyond recommended levels. While this escalation contributed to higher agricultural output (Patra et al., 2016), it also led to negative environmental consequences (Kumar et al., 2019). Excessive use of chemical fertilizers, especially nitrogen-based ones, has been shown to degrade soil health over time. Despite short-term gains in productivity, overuse contributes to the gradual loss of soil fertility and increased sterility of arable land. Additionally, nutrient runoff from over-fertilized fields contaminates nearby water bodies, exacerbating environmental degradation (Kagan et al., 2024).

In this context, it becomes crucial to investigate fertilizer use patterns in economically vulnerable regions. Kurigram, the poorest district in Bangladesh, represents a critical case study. Understanding whether farmers in this district, particularly those cultivating mustard, are overapplying chemical fertilizers and identifying the underlying reasons for such behavior is essential for promoting sustainable agriculture. This research is the first of its kind to examine the extent and drivers of chemical fertilizer use among mustard farmers in the Kurigram district, aiming to inform future policy and extension strategies. Therefore, the primary objectives of this research are as follows:

- To calculate the types and quantities of chemical fertilizers applied by smallholder farmers in the Kurigram district of northern Bangladesh.
- To evaluate whether the current levels of chemical fertilizer application by local farmers exceed agronomically recommended rates and environmental safety thresholds.
- To investigate the socio-economic, agronomic, and institutional factors driving the over-application of chemical fertilizers on agricultural lands in Kurigram.

2. Literature Review

Numerous studies have examined the implications of fertilizer use on agricultural productivity, soil health, and environmental sustainability. Ullah et al. (2008) highlighted the benefits of integrated nutrient management involving both organic and inorganic inputs in eggplant cultivation in Bangladesh, finding that such combinations not only improved yield but also enhanced soil fertility. This underscores the importance of optimizing the organic-to-inorganic ratio for sustainable crop production. Zhou et al. (2010) explored the factors influencing farmers' fertilizer use decisions and found that higher education and access to extension services significantly reduced the overapplication of chemical fertilizers. Their study also observed a negative relationship between farm size and manure use, and a positive correlation between fertilizer intensity and crop yield. The adverse environmental and health effects of agrochemical overuse in Bangladesh have been extensively documented. Rahman and Debnath (2015) attributed this issue to ignorance, poverty, illiteracy, and poor governance, advocating for effective policy implementation and the establishment of agricultural courts to regulate chemical use. They noted that pesticide use has increased by 150–300% since the 1950s, posing serious risks to both human health and ecosystems.

Islam and Hossain (2017) identified key socio-economic and demographic factors, such as age, education, income, training, and extension contact that influence excessive chemical fertilizer application among farmers in Rangpur, Bangladesh. Their findings emphasized the need for awareness campaigns and regulatory mechanisms to promote balanced agrochemical use. Beshir et al. (2012), using a double hurdle model in northeastern Ethiopia, found that education, access to extension services, credit availability, landholding size, gender, and income significantly influenced both the likelihood and intensity of inorganic fertilizer adoption. These determinants are consistent with findings in the South Asian context. Bhandari (2014) stressed that balanced application, optimal dosage, and timely administration of agrochemicals are critical to achieving increased crop productivity, especially given variability in soil and climatic conditions. Similarly, Savci (2012) emphasized that excessive chemical fertilizer using leads to environmental degradation, including soil nutrient imbalance, water pollution, and air contamination through nitrogen oxide emissions. He advocated for proper fertilization techniques and soil testing to mitigate these effects.

Environmental and health concerns have also been echoed by Raheem et al. (2020) and Jisna et al. (2021), who documented overapplication of agrochemicals by rural farmers without consideration of ecological consequences. In Sri Lanka, Jisna et al. found that excessive chemical use contributed to soil acidification and declining productivity, reinforcing the need for natural fertilizers and soil testing. Chakrabarty et al. (2014) identified knowledge gaps among both farmers and agrochemical dealers, noting that unawareness of recommended dosages and environmental impacts leads to excessive application. Dealers often encourage the use of larger quantities than necessary, exacerbating the issue. Rahman and Zhang (2018) highlighted how traditional broadcasting methods in fertilizer application contribute to overuse and environmental harm in Bangladesh. They recommended more efficient placement techniques and the adoption of earthworm-based organic manure to enhance sustainability, along with policy interventions to support these practices. Yilmaz et al. (2010) evaluated fertilizer subsidy policies and environmental outcomes in Turkey, revealing economic inefficiencies and ecological damage associated with overuse. These findings parallel challenges faced in Bangladesh and other developing nations. Reda and Hailu (2017) discussed the long-term effects of chemical fertilizers on soil health, particularly the suppression of microbial activity and enzyme function. They advocated for increased use of organic inputs and green manures to support soil regeneration and sustainability. Finally, Prakash (2023) addressed declining soil fertility linked to imbalanced fertilizer use and agricultural residue burning. He recommended eco-friendly practices such as the use of biofertilizers and earthworm composting to restore soil health and improve productivity.

There is a notable lack of micro-level, crop-specific analysis on fertilizer overuse, particularly in mustard cultivation, with limited research examining the extent of overuse relative to recommended doses at the union level in Bangladesh. Furthermore, although many farmers believe that increased fertilizer use guarantees higher yields, few studies have thoroughly investigated these perceptions or how they influence overuse behavior in the context of mustard farming. The literature also lacks sufficient empirical evidence linking farmer characteristics, such as age, education, experience, and training, to fertilizer overuse, especially in mustard production. In addition, there is a scarcity of studies that integrate primary field data with secondary data from local agricultural offices to provide a comprehensive understanding of fertilizer use patterns and to support policy formulation. While the environmental impacts of fertilizer use are broadly acknowledged, few studies focus on the localized effects of over-fertilization on the environment and biodiversity in mustard cultivation. Lastly, although awareness and training are often recommended, there is limited evaluation of the effectiveness of agricultural extension services and training programs in influencing farmer behavior regarding the excessive use of chemical fertilizers.

3. Methods and Materials

3.1 Study area: The study was carried out in the Nageshawari Upazila of Kurigram district. One of Bangladesh's 64 districts is Kurigram District. Nageshawari is one of the nine Upazilas in the area. It is situated 22 kilometers from Kurigram's main city and between 25˚ 59′and 26˚13′ north latitudes and between 89˚ 35’ and 89˚52′ Eastern longitudes. West Bengal and Assam in India border it on the north and east, while Kurigram Sadar Upazila and Fulbari Upazila in Bangladesh border it on the south and west.

3.2 Sampling procedure and sample size determination: Three stages of random sampling were used in this study to choose the sample farmers. In the first, the Kurigram district was chosen at random for the study, while the other districts in northern Bangladesh were left out. Using a straightforward random sample technique, Nageshawari Upazila was chosen in the second stage from among the nine Upazila in the Kurigram district. In the third phase, four unions and one municipality were chosen at random from among the fourteen unions and one municipality in Nageshawari Upazila. These are the unions of Newashi, Royganj, Bamandanga, Berubari, and Nageshawari municipality. In the initial stage of the study, Nageshawari Upazila was randomly selected as the research site. Following this, the researcher consulted with the Upazila Agriculture Extension Officer to discuss the objectives of the study. During this consultation, the officer provided valuable insights, particularly emphasizing that the recommended fertilizer dosages vary significantly from crop to crop. Consequently, selecting farmers without identifying a specific reference crop could have introduced confusion in the interpretation of fertilizer application data, as it would be unclear which crop's recommended dosage should serve as the benchmark.

To address this issue, the researcher first identified the major crops cultivated in the area. It was found that a significant number of farmers grow mustard as a second or third crop on their land. While several previous studies have focused on major cereals such as rice, wheat, and maize, often overlooking supplementary or rotational crops, the present study chose mustard in order to fill this research gap and provide a more comprehensive understanding of fertilizer usage patterns. Otherwise, although mustard is a widely cultivated and popular crop in Nageshwari Upazila, no prior academic studies have been conducted specifically on mustard cultivation in this region.

Farmers who grow mustard were chosen at random and interviewed to obtain the socioeconomic data and field-level data required to meet the study's goals. The research used an abridged formula to calculate the sample size that Yamane (1969) supplied to calculate the necessary sample size at a 95% confidence level, a 0.5 degree of variability, and a 9% level of precision. The sample is representative of the actual population when the sample size is calculated using the suggested formula. Below is the formula:

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

Where *N* is the farmers who cultivate mustard, e is the degree of precision, often known as sampling error (0.09), and n is the necessary sample size. The total number of farmers, during the cultivating year 2023-24, was 31,037 (UAEO, 2024). The researcher used farmers as a population and found that the total sample size

$$n = \frac{31037}{1+31037\ (0.09^2\ )} = \frac{31037}{1+31037(0.0081)} = \frac{31037}{252.39} = 122.97 \text{ or } 123 \text{ Farmer}$$

The researcher in this study examined around 250 mustard growers from four unions and one municipality to obtain a decent outcome.

3.3 Methods of data collection: To fulfil the objective of the study, a questionnaire was designed to gather information. Through in-person interviews, the researcher himself obtained the relevant data from the respondents in 2024. Secondary data were collected from BBS, books, journals, articles, the internet, Bangladesh Economic Review, and the Upazila Agriculture Extension Office (UAEO).

3.4 Analytical technique: Chemical fertilizers are artificial substances that are applied to the soil or plant tissues to ensure the supply of various nutrients to plants. However, excessive use of fertilizers adversely affects soil and crop quality. To maintain soil and crop quality, the Bangladesh Agricultural Research Council has given guidelines on chemical fertilizer dosage recommendations depending on several types of crops and different types of land. However, studies show that farmers in Bangladesh do not follow the recommended doses of chemicals in their agriculture; rather, they apply excessive amounts of chemical fertilizers. In this study, excess doses of chemical fertilizers were measured by comparing the actual doses applied by farmers with the doses recommended in the 'Bangladesh Fertilizer Recommendation Guidelines, 2024'. The calculation can be performed through the following equation:

$$\textit{Fertilizer overdoses} = \textit{Actual dose used by farmers}\ (kg) - \textit{Recommended dose}\ (kg)$$

If farmers apply more than the recommended dose (actual dose) of chemical fertilizers to their land, it is considered an overdose. To identify the determinants of the use of fertilizer and pesticide in agriculture, OLS regression is run. In this study, overdose use of chemical fertilizer is the dependent variable, and age (Islam & Hossain, 2016), education (Rahman & Debnath. 2015), experience, training (Islam & Hossain, 2017), extension contacts (Zhou et al., 2010), and farm size (Behir et al., 2012) are the independent variables. The Ordinary Least Squares (OLS) model is as follows-

For the overdose use of chemical fertilizers,

$$Odi = \theta_0 + \theta_1 Agei + \theta_2 Edui + \theta_3 Faexi + \theta_4 Famsi + \theta_5 Trai + \theta_6 Exti + \theta_7 Subi + \theta_8 Farsi + u_i$$

where,
Overdose use of chemical fertilizers (kg.) = Od
Age of farmers (year) = Age
Education of farmers (years of schooling) = Edu
Experience of farmers (year) = Faex
Training on agriculture = Trai
Extension contracts = Ext
Farm Size (*bigha*) =Fars
Stochastic disturbance term = u_i

4. Results and Discussion

Farmers in the study area primarily utilized chemical fertilizers to enhance crop yields on their land. The majority of these farmers were illiterate and held the perception that increased application of chemical fertilizers would result in higher mustard production. Consequently, they did not follow the recommended application rates outlined for mustard cultivation. Instead, most farmers applied fertilizers based on their judgment, often exceeding the prescribed dosages.

The application of fertilizer in quantities greater than the recommended rate is classified as excessive use or overuse. The extent of this overapplication, along with the officially recommended doses specified in the *Fertilizer Recommendation Guide, 2024*, issued by the Upazila Agriculture Extension Office, is detailed in Tables 1, 2, and 3. These guidelines are specific to mustard production in the study region. Adherence to the recommended fertilizer dosages would enable farmers to achieve higher yields at reduced costs. However, field evidence suggests that most farmers do not comply with these guidelines. Therefore, examining the current patterns of fertilizer application is essential for understanding this relationship, which is addressed in detail in the subsequent sections of this chapter. The recommended doses of chemical fertilizer for mustard production are shown in Table 1.

Table 1. Recommended Doses of Chemical Fertilizers for Mustard Production

Crops	**Name of Fertilizer**	**Recommended Doses (kg/bigha)**
All varieties of mustard	Urea	26.10
	TSP	18.07
	MP	8.57
	Gypsum	12.45
	Zinc sulphate	0.75
	Boric acid	0

*Source: Agriculture extension office, Nageshwari

Table 2 presents the average quantity of chemical fertilizers applied per bigha for mustard cultivation in the study area. The data indicates a diverse use of fertilizers, reflecting efforts to ensure optimal nutrient availability for mustard production. Among the various inputs, Urea is the most widely used fertilizer, with an average application rate of 36.98 kg per bigha, signifying the high nitrogen demand of the crop. Triple Super Phosphate (TSP) follows with an average of 34.20 kg per bigha, highlighting the importance of phosphorus in enhancing root development and flowering. Gypsum, used to improve soil structure and calcium availability, is also applied in significant quantities, averaging 20.30 kg per bigha. Other fertilizers such as Muriate of Potash (MP), Boric acid, and Zinc sulphate are applied at lower rates—15.57 kg, 2.65 kg, and 1.84 kg per bigha, respectively. These inputs contribute essential micronutrients like potassium, boron, and zinc, which are crucial for overall plant health, disease resistance, and improved yield quality.

Table 2. Average Use of Chemical Fertilizer for Mustard Production

Chemical Fertilizer	Average Application (per bigha)
Urea	36.98
Boric	2.65
Gypsum	20.30
Zinc sulphate	1.84
TSP	34.20
MP	15.57

The data clearly show that farmers tend to apply all major fertilizers—Urea, TSP, MP, Gypsum, and Zinc sulphate—in quantities significantly higher than the recommended levels. Notably, the use of Boric acid, which is not included in the official recommendations, suggests a local adaptation or a perceived benefit not supported by standard agronomic guidelines.

The excessive use of chemical fertilizer amount and percent rate are shown in the following Table 3.

Table 3. The Rate of Excessive Use of Chemical Fertilizer

Fertilizer	Excess Fertilizer Amount (kg)	Percent Excess Fertilizer User	Total User	Percent of Farmers
Urea	1-5	13.86	238	95.2%
	6-10	28.57		
	11-15	28.99		
	16-20	18.48		
	21-25	10.08		
Boric acid	1-3	70.49	61	24.4%
	4-6	22.95		
	7-10	6.55		
Gypsum	1-5	50.90	165	66%
	6-10	37.57		
	11-15	11.51		
Zinc sulphate	1-3	96.8	250	100%
	4-6	2.4		
	7-10	0.8		
TSP	1-5	9.28	237	94.8%
	6-10	13.50		
	11-15	23.62		
	16-20	24.89		
	21-25	28.69		

MP	1-5	35.71	224	89.6%
	6-10	41.07		
	11-15	11.60		
	16-20	11.60		
Average percent				78.33%

Table 3 shows that the average excessive use of chemical fertilizer by farmers is about 78.33%. The amount of recommended dose of Urea, Boric acid, Gypsum, and Zinc sulfate. TSP and MP fertilizers in mustard land were 26.104, 0, 12.449, 0.749, 18.072, and 8.567 kg per bigha during the season. That means they need to apply only 26.104 kg of Urea, 0 kg of Boric acid, 12.449 kg of gypsum, 0.749 kg of zinc sulfate, 18.072 kg of TSP, and 8.567 kg of MP fertilizer per bigha in their mustard land. The findings reveal that a substantial proportion of farmers applied fertilizers over the recommended dosages per bigha in mustard cultivation. Specifically, approximately 95.2% of farmers overused Urea, 24.4% applied excess Boric acid, 66% exceeded the recommended amount of Gypsum, 100% overapplied Zinc sulfate, 94.8% used excess TSP, and 89.6% applied more than the recommended quantity of MP.

This study found that farmers use excessive chemical fertilizers on their agricultural land. There are many reasons for using excessive chemical fertilizers. Here, the determinants of using excessive doses of chemical fertilizers are estimated using a regression model. For estimation, the OLS method is employed. Here, regression is run for the average overdose use of fertilizers in mustard cultivation, which is considered a dependent variable. On the other hand, age, education, farming experience, agricultural training, extension contact, and farm size are considered as independent variables. The regression serves to understand the determinants of using chemical fertilizers in agriculture. Estimation results for determinants of using excessive doses of chemical fertilizers in agriculture are provided in Table 4.

Table 4. Determinants of Excessive Chemical Fertilizer Use in Mustard Cultivation

Variables	**Coefficient**	**Std. Error**	***t*-value**	***p*-value**
Constant	18.62***	0.717	25.988	0.000
Farm size	-0.06	0.005	-1.506	0.133
Age of farmers	-0.19***	0.019	-4.806	0.000
Education of farmers	-0.36***	0.048	-7.798	0.000
Training	-0.21***	0.901	-3.513	0.001
Extension contract	-0.02	1.112	-0.285	0.776
Farming experience	-0.24***	0.055	-3.743	0.000
R-squared		.91		
Adjusted R-squared		.89		

Note: *** indicates significance at the 1 % level.

The estimated coefficient of the different determinants of excessive use of chemical fertilizers is presented in Table 4. It is evident from the *p*-value results that all the included variables in the model are important for explaining the decision to use an overdose of fertilizer by farmers, except for extension contact and farm size, which are also negatively related to the overdose use of fertilizer. The value of R^2 also indicates that about 91.00 percent of the variation in overdose use has been explained by the included variables. It was observed that the regression analysis showed a negative and insignificant coefficient for farm size in the overdose use of fertilizer. The value of the coefficient was .058, indicating that it has no severe effect on the excessive use of fertilizer. The study indicates that age is one of the key variables and plays an important role. The variable age of farmers is significant at the 1% level. The value of the coefficient of age of farmers is -0.191. It showed that a 1-year increase in the age of the farmers, keeping other factors constant, could decrease the use of overdose chemical fertilizers by 0.191 kg. It is also found that education is one of the key variables and plays a significant role. The variable education of farmers is significant at the level of 1%. The value of the coefficient of education of farmers is -0.363. It showed that a 1-year increase in schooling, keeping other factors constant, could decrease the use of overdose chemical fertilizers by 0.363 kg. It was found that the regression analysis showed that the coefficient of the agricultural training was negative and significant for overdose use of fertilizers at a 1 percent significance level, which indicates that if the farmer gets additional training in agriculture, keeping other factors constant, it could decrease the use of overdose chemical fertilizers by 0.209. The variable extension contact is insignificant. It showed that it has no severe effect on the excessive use of fertilizer. The variable farming experience is significant at the level of 1%, and its value is -0.241. It showed that a 1-year increase in experience of farming, keeping other factors constant, could decrease the use of overdose chemical fertilizers by 0.2 kg. That means elder farmers are applying less fertilizer on their farms. Similar results had been reported by Islam and Hossain (2016) based on the data from Bangladesh.

Several sources that influenced the amount of fertilizer used in the decision of mustard are discussed in this section. These sources were obtained by asking the farmers when the data were collected. The following Table 5 shows the sources of fertilizer application decisions. The data presented in Table 5 illustrate the various sources from which farmers derive their decisions regarding fertilizer application. A significant majority of farmers (56.8%) rely on their own judgment when determining the quantity and type of fertilizers to apply. This indicates a strong dependence on personal experience and intuition rather than on scientific or extension-based guidance. Only a small proportion of farmers (9.2%) reported consulting agricultural specialists, and even fewer (2%) obtained fertilizer information online, suggesting limited access to or utilization of formal or digital advisory services. Meanwhile, 10.8% of farmers make decisions based on discussions with neighboring farmers, reflecting the importance of peer influence within local agricultural communities. Other sources include consultations with relatives (8.8%) and fertilizer shopkeepers (8.4%), indicating that non-expert and commercial actors also play a role in influencing fertilizer use decisions. A small percentage (4%) reported relying on other unspecified sources. These findings underscore the need to strengthen formal agricultural extension systems and digital advisory platforms to ensure that farmers receive accurate and environmentally sustainable guidance on fertilizer application.

Table 5. Fertilizer Application Decision Sources of the Farmers

Decision Sources	**No. of Farmers**	**Percentage**
Own self	142	56.8
Discuss with relatives	22	8.8
From specialist	23	9.2
From online	5	2
From the neighbouring farmers	27	10.8
Fertilizer shop	21	8.4
Others	10	4

Table 6. Multicollinearity Diagnostic (VIF Values)

Independent variable	**Tolerance**	**VIF**
Age	0.950	1.052
Farm size	0.946	1.057
Education	0.804	1.244
Training	0.954	1.048
Farming experience	0.785	1.274
Extension contact	0.934	1.071

Table 6 presents the results of multicollinearity diagnostics using the Variance Inflation Factor (VIF) and tolerance values for all independent variables included in the regression model. The results indicate that multicollinearity is not a concern in this study, as all VIF values are well below the commonly accepted threshold of 5. The highest VIF observed is 1.274 for Farming experience, followed by 1.244 for Education. Similarly, the tolerance values for all variables exceed 0.1, further supporting the absence of serious multicollinearity. These findings confirm the reliability of the regression estimates and suggest that the independent variables do not significantly overlap in explaining the variation in the dependent variable.

5. Conclusion and Policy Recommendations

This study investigated the extent and determinants of excessive chemical fertilizer use in mustard cultivation in Nageshwari Upazila. The findings revealed that a significant majority of farmers applied chemical fertilizers beyond the recommended doses, particularly Urea (95.2%), TSP (94.8%), and Zinc sulfate (100%). This overuse is primarily attributed to a lack of awareness and misinformation, as many farmers believe that higher fertilizer input guarantees higher yields. However, such practices not only increase production costs but also pose serious threats to environmental and human health. Regression analysis showed that farmer age, education level, training, and farming experience significantly and negatively influence excessive fertilizer use, indicating that informed and experienced farmers are less likely to overuse chemical inputs. Conversely, farm size and extension contact did not have a significant effect. Multicollinearity diagnostics confirmed the reliability of the regression estimates. The environmental consequences of excessive chemical fertilizer use include soil degradation, water and air pollution, ecosystem imbalances, and health hazards. Moreover, continued reliance on chemical fertilizers without appropriate management reduces soil fertility and increases future dependency on artificial inputs to maintain yields.

To mitigate these challenges, the following policy recommendations are proposed: The government needs to establish a programme that focuses on improving soil health, the impact of excessive fertilizer use on the environment, and biodiversity. This study finds that the majority of mustard farmers applied excessive amounts of fertilizer on their land, which not only concerns biodiversity but also human beings. So, govt. should establish a farmers' Agri-knowledge center to raise awareness about the negative impact of excessive fertilizer and ensure economic benefits with low fertilizer costs. The agriculture extension department must properly monitor at the field level. The government should collaborate with international organizations to share knowledge, experience, and sustainable agriculture, contributing to a global effort to address excessive use of fertilizer. More herbicides have some health hazards to other cultivable land. So, the use of herbicides should be reduced as little as possible based on need. The government must adopt proper laws for over-dose use of fertilizer. Otherwise, these chemicals will affect both humans and animals.

References

Akteruzzaman, M., Jahan, H., & Haque, M. E. (2012). Practices of conservation agricultural technologies in diverse cropping systems in Bangladesh. *Bangladesh Journal of Agricultural Economics*, *35*, 143-153.

Baweja, P., Kumar, S., & Kumar, G. (2020). Fertilizers and pesticides: Their impact on soil health and the environment. *Soil Health*, 265-285.

BBS. (2019). Report on agriculture and rural statistics. *Agriculture and Rural Statistics Survey* (ARSS) *Project*-2017.

Beshir, H., Emana, B., Kassa, B., & Haji, J. (2012). Determinants of chemical fertilizer technology adoption in North Eastern Ethiopia: the double hurdle approach. *Journal of Research in Economics and International Finance* (JREIF) *1*(2), pp. 39-49.

Bhandari, G. (2014). An overview of agrochemicals and their effects on the environment in Nepal. *Applied Ecology and Environmental Sciences, 2*(2), 66-73.

Chakrabarty, T., Akter, S., Saifullah, A., Sheikh, M. S., & Bhowmick, A. C. (2014). Use of fertilizer and pesticide for crop production in the Agrarian area of Tangail district, Bangladesh. *Environment and Ecology Research 2*(6)*:* 253-261.

Gupta, R. D., & Gupta, S. K. (2016). Strategies for increasing the production of oilseed on a sustainable basis. In *Breeding Oilseed Crops for Sustainable Production*, Academic Press, 1-18.

Islam, M. K., & Hossain, M. E. (2016). Factors affecting the adoption decision of high doses of chemical fertilizer and pesticide in agriculture in Rangpur district of Bangladesh. *International Journal of Management and Economics Invention, 2*(7), pp. 681-689.

Islam, M. K., & Hossain, M. E. (2017). Do Farmers use overdosed chemical Fertilizer in Agriculture? Empirical evidence from Northern Bangladesh. *Rajshahi University Journal of Social Science and Business Studies*, *25*, 63-75.

Jisna, M. F., Nuskiya, M., & Iyoob, A. (2021). The excessive use of chemical fertilizers & dynamic soil pH on agricultural land: The GIS-based inverse distance weighting (IDW). *World News of Natural Sciences* (WNOFNS), *39*, 113-129.

Kagan, K., Jonak, K., & Wolińska, A. (2024). The impact of reduced N fertilization rates according to the "Farm to Fork" strategy on the environment and human health. *Applied Sciences, 14*(22), 10726.

Karim, R., Pk, M. B., Dey, P., Akbar, M. A., & Osman, M. S. (2024). A study about the prediction of population growth and demographic transition in Bangladesh. *Journal of Umm Al-Qura University for Applied Sciences*, 1-13.

Kiron, M. A., & Islam, M. K. (2023). Profitability analysis of boro rice farming: The case of Naogaon district of Bangladesh. *Agricultural Socio-Economics Journal*, *23*(3), 327-343.

Kumar, R., Kumar, R. and Prakash, O. (2019). The impact of chemical fertilizers on our environment and ecosystem. In: Sharma, P., Ed., *Research Trends in Environmental Sciences*, Chapter 5. AkiNik Publications, New Delhi, 69-86.

Mondol, H., Mallick, U. K., & Biswas, M. H. A. (2018). Mathematical modeling and predicting the current trends of human population growth in Bangladesh. *Modelling, Measurement & Control D: 39*(1), 1-7.

Patra, S., Mishra, P., Mahapatra, S. C., & Mithun, S. K. (2016). Modelling impacts of chemical fertilizer on agricultural production: a case study on Hooghly district, West Bengal, India. *Modeling Earth Systems and Environment*, *2*, 1-11.

Prakash, D. O. (2023). Excessive use of chemical fertilizers reduces the fertility of the soil. *International Journal of Engineering Inventions*, *12*(8), 116-118.

Raheem, S. M., Rasul, H. I., & Harun, R. (2020). Farmer's behavior and attitude in using chemical fertilizers and Pesticide in Rural Areas and its Effects on the Environment. *Journal of Plant Production, Mansoura University, 11*(11), 1077-1081.

Rahman, K. M., & Debhnath, S. C. (2015). Agrochemical use, environmental and health hazards in Bangladesh. *International Research Journal of Interdisciplinary & Multidisciplinary Studies* (IRJIMS), *1*(6), 75-79.

Rahman, K., & Zhang, D. (2018). Effects of fertilizer broadcasting on the excessive use of inorganic fertilizers and environmental sustainability. *Sustainability*-(*MDPI*), *10*, 759.

Reda, A., & Hailu, A. H. (2017). Extensive utilization of inorganic fertilizers in Ethiopian agriculture and its possible consequences on soil quality. *World Journal of Agricultural Sciences 13* (4), 155-171.

Savci, S. (2012). Investigation of effect of chemical fertilizers on environment. *APCBEE Procedia 1*, 287-292.

Ullah, M., Islam, M., Islam, M., & Haque, T. (2008). Effects of organic manures and chemical fertilizers on the yield of brinjal and soil properties. *Journal of Bangladesh Agricultural University*. *6*(2), 271-276.

Yilmaz, H. A. S. A. N., Demircan, V. E. C. D. İ., & Gul, M. (2010). Examining of chemical fertilizer use levels in terms of agriculture environment relations and economic losses in the agricultural farms: The case of Isparta, Turkey. *Bulg J Agric Sci*, *16*(2), 143-157.

Zhou, Y., Yang, H., Mosler, H.-J., & Abbaspour, K. C. (2010). Factors affecting farmers' decisions on fertilizer use: A case study for the Chaobai watershed in Northern China. *The Journal of Sustainable Development, 4*(1), 80-102.