Faculty of Science and Engineering

School of Geography, Earth and Environmental Sciences

2013-12-16

# Impact of urea price change on the economic optimum level of N fertilizer use in HYV rice and its yield in Bangladesh

# Rahman, Sanzidur

http://hdl.handle.net/10026.1/10812

Bangladesh Journal of Agricultural Economics Bangladesh Agricultural University, Mymensingh

All content in PEARL is protected by copyright law. Author manuscripts are made available in accordance with publisher policies. Please cite only the published version using the details provided on the item record or document. In the absence of an open licence (e.g. Creative Commons), permissions for further reuse of content should be sought from the publisher or author.

**ISSN 0237-3539** 

# THE BANGLADESH JOURNAL OF AGRICULTURAL ECONOMICS

Volume XXXVI June and December 2013 Number 1 & 2

#### Articles

Effects of Remittances on Human Capital Development: An empirical analysis- Lavlu Mozumdar and Mohammad Amirul Islam

Changes in Marketing System of Raw Jute in Bangladesh – M. M. U. Molla, S. A. Sabur and I. A. Mia

A Comparative Analysis of Sustainability in Crop and Dairy Production System in Tamil Nadu, India – J. S. Amarnath and M. Brindha

#### **Research Notes**

Livestock Products Consumption Pattern in Selected Areas of Bangladesh – M. M. O. Rashid

Impact of Urea Price Change on the Economic Optimum Level of N Fertilizer Use in HYV Rice and its Yield in Bangladesh – Sanzidur Rahman, Mohammad Mizanul Haque Kazal and Shaikh Tanveer Hossain

Change in Cropping Patterns and its Impacts on Farmers' Livelihood in Some Selected Areas of Mymensingh District – A. S. M. Ferdush Pervez, M. Saidur Rahman and A. K. M. Abdullah Al-Amin

Evaluating Interventions in Developing Country Agriculture: The Productive Efficiency and Related Analytical Issues – Md. Abdur Rouf

The Half Yearly Journal of THE BUREAU OF SOCIOECONOMIC RESEARCH AND TRAINING BANGLADESH AGRICULTURAL UNIVERSITY MYMENSINGH Bangladesh J. Agric. Econs. XXXVI, 1&2 (2013) 63-76

#### **Research** Note

# IMPACT OF UREA PRICE CHANGE ON THE ECONOMIC OPTIMUM LEVEL OF N FERTILIZER USE IN HYV RICE AND ITS YIELD IN BANGLADESH

#### Sanzidur Rahman<sup>1</sup> Mohammad Mizanul Haque Kazal<sup>2</sup> Shaikh Tanveer Hossain<sup>3</sup>

#### Abstract

The study estimates the impact of change in urea price on the economic optimum level of N fertilizer use in HYV rice and its yield in Bangladesh using a large set of experimental data of BRRI from 15 regions covering an 11 year period (2001–2011). Results revealed that the level of N fertilizer used in experiments to increase HYV rice yield was far lower than the economic optimum level in Aman and Boro seasons but higher in Aus season. The discrepancy was highest for HYV Boro rice closely followed by HYV Aman rice. Simulation ecvercise revealed that an increase in real price of urea by 50% will exert a 4% reduction in optimum dose of N fertilizer in HYV Aman rice and reduce yield by 101.2 kg/ha which is substantial. The corresponding effect on HYV Boro rice is relatively lower and negligible for HYV Aus rice. The result highlights the dilemma and the detrimental effect of urea price increase on the yield of HYV Aman rice which is the main source of foodgrain supply for the nation. Therefore, price policy should be geared towards controlling relative price of urea which can be met by a combination of subsidizing urea price and/or improving rice price.

Key Words: Economic optimization, N fertilizer, HYV rice yield, Simulation, Bangladesh.

#### I. INTRODUCTION

Rice is the staple food of Bangladeshi diet and will remain as such in the foreseeable future despite area under other cereals, particularly wheat and maize, is rising gradually over time. Rice alone occupies 79.2% of gross cropped area (Rahman and Kazal, 2015). It is largely believed that the efforts in countrywide diffusion of a rice-based 'Green Revolution' (GR) technology since the beginning of the 1960s tofulfil the goal of foodgrain self-sufficiency have largely been paid off in recent years (Rahman, 2010). In fact, rice productivity has increased remarkably with Bangladesh topping the list in Asia. For example, productivity of rice increased from only 1.68 t/ha in 1961 to a high 4.36 t/ha in 2013, thereby beating Sri Lanka who enjoyed higher yield levels during the 1960s and 1970s (Table 1).

<sup>&</sup>lt;sup>1</sup> Associate Professor, School of Geography, Earth and Environmental Sciences, University of Plymouth, UK, Email: srahman@plymouth.ac.uk

<sup>&</sup>lt;sup>2</sup> Department of Development and Poverty Studies, Sher-e-Bangla Agricultural University, Dhaka

<sup>&</sup>lt;sup>3</sup> Friends In Village Development Bangladesh (FIVDB)

Nevertheless, productivity of rice in Bangladesh can be increased furtherby increasing adoption rate of the GR technology package in full, particularly by improving nutrient management. One of the main pillars of successful outcome of a rice-based GR technology is the use of inorganic fertilizers, particularly application of the three major nutrients (i.e., N, P and K fertilizers) to support plant growth and grain yield of the High Yielding Varieties (HYV) of rice. Ahmed (2001) noted that the level of total fertilizer use in Bangladesh is 40-70% below recommended level. There is a significant gap in the use of N, P, K fertilizers between the recommended and actual level for all three growing seasons of rice. The gap is more significant for phosphate and potassium fertilizers (estimated at 64.1-72.3% for TSP and 69.1-75.4% for MP) as compared to urea (estimated at 4.3-28.6% for urea) in Bangladesh (MoA, 2004 cited by Jaim and Akter, 2012). Mujeri et al. (2012) noted that the current pattern of fertilizer use with heavy reliance on nitrogenous fertilizer coupled with poor nutrition management and weak marketing and distribution systems have emerged as major constraints in improving the effectiveness in fertilizer use in South Asia. They have also emphasized that due to lack of efficiency and effectiveness in fertilizer use, there is concern regarding sustainability of fertilizer use.

Country	1961	1971	1981	1991	2001	2013
Bangladesh	1.68	1.58	1.94	2.59	3.31	4.36
Bhutan	1 44	1.44	1.46	1.25	1.44	2.94
India	0.95	1.14	1.40	1.93	2.42	2.96
Nepal	1.85	1.72	1.70	1.85	2.18	2.57
Pakietan	0.86	1.20	1.67	1.81	2.23	2.72
Sri Lanka	1 77	1.94	2.55	2.93	3.42	3.83
Asia	1.21	1.67	2.15	2.83	3.17	3.94

<b>Fable 1. Productivit</b>	y of rice (mt/h	a) in Asia (1961–2013)
-----------------------------	-----------------	------------------------

Note: Compiled from World Agriculture Statistics database (FAOSTAT, various issues).

#### 1.1 Fertilizer subsidy in Bangladesh

Since the introduction of the GR technology in the 1960s, the Government of Bangladesh (GoB) had undertaken a range of policies to facilitate widespread use of inorganic fertilizers by the farmer by controlling its prices, distribution and marketing system which is summarised in Table 2. When fertilizer was first introduced in Bangladesh, it was heavily subsidized with monopolistic control by Bangladesh Agricultural Development Corporation (BADC). Since then various measures were undertaken to simplify the procurement and distribution system of fertilizers while maintaining control by the government. It is only during the 1990s, when greater liberalization of the fertilizer sector was initiated which showed considerable success during its initial years. However, during the last decade, privatization of the fertilizer sector led to several episodes of crises, particularly for urea fertilizer. The government then reverted back to heavy level of subsidy in fertilizers from 2012, the outcome of which is not yet fully realized. Table 3 clearly shows that the level of fertilizer subsidy in Bangladesh has increased 60 times in a space of 12 years from only BDT 1.0 billion in 2001/02 to BDT 59.9 in 2012/13 in real terms (Mujeri et al., 2012 and MoA, 2014).

			0		
Period	Policy	Main actor	Procurement	Distribution	Outcome
1950 -	High level of subsidy	BADC	BADC alone responsible for procurement from	BADC appointed dealers to collect fertilizer from	Time consuming; Erratic supply at times of need BADC has limited
	(1975/76);		domestic producers,	BADC distribution	transportation and storage
	Sale price fixed by GoB		donor-supplies and imports	points and deliver to farmers at fixed prices	capacity, low commission to dealers acted as deterrent
- 7791	New Marketing System	BADC:	BADC alone responsible	BADC appointed	Increased farmer's access to
1987	supported initially by	Private	for procurement from	dealers to collect	fertilizer sources;
	USAID project in	sector	domestic producers,	fertilizer from more	Lowered/deregulated retail
	1977/78; Botoil	dealers	donor-supplies and	primary distribution	prices; Consolidated government warehousing: Produced a
	dereculation: price		subolin	farmers at commetitive	minimal effect on the
	Substantial reduction of		A 20.40	prices	government's distribution costs;
•	subsidy to only 4% in 1982/83				Lifting of tertilizer by dealers were still time-consuming
1987 -	New Marketing System	IFDC	Dealers to procure from	Private dealers to sell to	Lower farm level prices of
1989	continuing; Subsidy is	through	port and factories	farmers at market prices	fertilizers
	still maintained by	MoA	directly		- - 
	reduction in fertilizer				
	prices under command area of dealers				
- 0661	Privatization of the	Dealers and	Dealers and private	Private sector	Significant economies of scale
1994	fertilizer market;	private	companies are free to	responsible for all types	achieved; substantial reduction
	Subsidy of fertilizers	companies	import all types of	of distribution and sale	in real farm level prices; fortilizer no increased of an
	partially removed (remained for urea)		fertilizers	at market prices	average rate of 8.5% per year;
					Bangladesh received self-
	•				sufficiency in rice production in 1993/94: Bangladesh Fertilizer
					Association created in 1993;
			20 1		

65

2. Key policy changes in fertilizer pricing, distribution and marketing system in Bangladesh

Impact of Urea Price Change on The Economic

.*					
Period	Policy	Main actor	Procurement	Distribution	Outcome
- 5991	Reintroduction of	Judicial	Dealers and private	Private sector	Several fertilizer crises during
2008	subsidies upto 25% for	commission	companies are free to	responsible for all types	this privatization period of Open
	phosphate and	appointing	import all types of	of distribution and sale	Market Sale policy; weak policy
	potassium fertilizers	district level	fertilizers	at market prices	failed to implement effectively
8	due to hike in world	dealers:			
	prices during 2003/04;				and the second
	New Dealership Policy				
	in 2008 to appoint one				
	dealer for each union				
2009 -	Subsidy on fertilizers	<b>BCIC</b> ;	BCIC controlling	BADC and private	Several episodes of urea
2011	maintained; New	Abolition of	production and import of	sector responsible for	fertilizer crises in 2007, 2008
	Dealership Policy 2009	sales	urea	all types of distribution	and 2009
	introduced;	representativ	8	and sale at market	
	Open market sale re-	e of dealers,		prices	
	introduced	restriction of			
		dealership	1		AND SALES PLANNES AND THE SALES
5 1 1		within the			
		district; use			
		of ID card			
21		for dealers			
2012 -	Heavy subsidy on	BCIC;	BCIC controlling	BADC and private	Drastic reduction of TSP, MP
	fertilizers continued	BADC	production and import of	sector responsible for	and DAP prices through subsidy
			urea	all types of distribution	
				prices;	
2013 -	National Agricultural	GoB and	GoB and private sector	GoB and private sector	No specific outcome available
	Policy 2013 launched	Private	can purchase and	to distribute and sell to	
		sector, GoB	procure fertilizers; GoB	farmers	
		to monitor	will ensure storage at		
		the fertilizer	regional, district and	3	
		sector	upazila level for		
2			emergencies		•
Source: Con	noiled from Mujeri et al. (2	(012); Barkat e	t al. (2010); Jaim and Akte	r (2012); MoA (2013).	**************************************

The Bangladesh Journal of Agricultural Economics

66

Year	is nation still	Total amount (in billion Taka at current prices)	Total amount (in billion Taka at constant prices)
2001-02		1.0	1.0
2002-03		2.0	1.9
2003-04		3.0	2.7
2004-05		6.0	5.1
2005-06		12.0	9.5
2006-07		15.4	11.4
2007-08		22.5	15.1
2008-09		57.9	36.5
2009-10		49.5	29.1
2010-11		55.21	30.7
2011-12		69.93	36.8
2012-13		119.93	59.9

#### Table 3. Fertilizer subsidy in Bangladesh

Source: Compiled from Mujeri et al. (2012) and MoA (2014).

#### 1.2 Impact of fertilizer subsidy

Literature on the impact of subsidy on inputs, particularly fertilizers, is mixed. For instance, Barker and Hayami (1976) noted that subsidy of modern inputs (e.g., fertilizer) that was being used below optimum level can be more beneficial than supporting product prices. In contrast, Ahmed (1978) concluded that for any reduction in the budgetary burden of subsidy, the government should explore price support programme before reducing fertilizer subsidy. Bayes *et al.* (1985) concluded that some combination of price support and fertilizer subsidy is preferable to achieve rice self-sufficiency in Bangladesh. Renfro (1992) noted that the liberalization of fertilizer marketing and price policies in Bangladesh had led to an expanded role for the private sector and benefited farmers in reduced prices and timely supply of fertilizers. Zahir (2001) revealed that reduction of subsidy would reduce farmers' profit (net income) which could adversely affect crop sector growth. Begum and Manos (2005) also showed that a policy of increased price of fertilizer (i.e., reduction of subsidy) would have a huge impact on farm income and employment.

It is apparent that the agricultural input subsidy policies (i.e. diesel and fertilizers) were devised by GoB as a tool for allowing a 'level playing field' for the Bangladeshi farmers in a trade liberalized era, whereas farmers in India were receiving subsidies for several inputs, e.g., irrigation, electricity, etc. Islam *et al.* (2007) found that the farmers in general were using excessive urea and comparatively fewer amounts of TSP and MP, while converse is also found in some cases. Kafiluddin and Islam (2008) showed that the prices of TSP, DAP and MP increased abruptly in the international market during 2003/04 which has adversely affected balanced use of fertilizer. However, reintroduction of subsidy in phosphate and potassium fertilizers from 2005/06 improved fertilizer use and crop production increased significantly in the country. <u>Barkat *et al.*</u> (2010) suggested subsidy scheme targeted for small farmers as they have limited opportunities to cope with price changes. Jaim and Akter (2012)

also noted that the liberalization of fertilizer market did not take into account effects on small and marginal farmers and resulted in inefficiencies, price hikes, fertilizer crises, overuse and adulteration. Mujeri *et al.* (2012) also noted adulteration of fertilizers in South Asia.

Given this backdrop of circular policy changes in fertilizer pricing, distribution and marketing system and mixed account of the impact of such policies at the farm level including unbalanced and gaps in fertilizer use, it is important to identify the impact of fertilizer price change on the economic optimum level of fertilizer use in rice and corresponding yield levels. Therefore, the specific objectives of this study are to: (1) determine the economic optimum level of nitrogen (N) fertilizer use in HYV rice for each of the three cropping seasons (i.e., Aus, Aman and Boro seasons); and (2) estimate the impact of urea price change on the economic optimum level of N fertilizer in HYV rice and its yield for all three seasons.

This task was undertaken by using a large data set of fertilizer trials on HYV rice of three growing seasons of the Bangladesh Rice Research Institute (BRRI) covering an 11 year period (2001–2011). The advantages of using such dataset are as follows: (1) since these are experiments, scientists keep an accurate record of fertilizer doses; (2) plot size of experiments are uniform; (3) the assumption of *ceteris paribus* (i.e., all other things being equal) for all other inputs is maintained with variation in fertilizer doses only (which satisfy the main requirement of this study); (4) since these experiments were conducted on different varieties of HYV rice of three seasons at multiple testing sites of BRRI over time, we can control for variations in agroecology, production environment and time. Therefore, the main contributions of our study to the existing literature are as follows: (1) it aims to provide an accurate account of economic optimum level of N fertilizer use in HYV rice cultivation for each of the three growing seasons while accounting for variation in varietal differences, agroecological and production conditions and time; and (2) it provides a scenario analysis of urea price change on the economic optimum level of N fertilizer use in HYV rice and its yield for all three seasons.

## 2.1 Analytical framework

### **II. METHODOLOGY**

The main objective of this study is to determine the economic optimum level of N fertilizer use in HYV rice and its yield for all three growing seasons. The basic modelling framework is as follows:

Let Y be the yield of rice per ha and X be the fertilizer use rate per ha. Assuming all other inputs being equal, then the quadratic yield response function can be fitted as:

$$Y = \alpha + \beta X + \gamma X^2 + \varepsilon \tag{1}$$

where  $\alpha$ ,  $\beta$ , and  $\gamma$  are the parameters to be estimated, and  $\epsilon$  is the error term.

The first order condition yields:

$$\frac{dy}{dx} = \beta + 2\gamma X = 0 \qquad (2)$$

Solving this first order condition, i.e., Eq (2) for X provides the yield maximizing level of X afertilizer use only, but not the economic optimum. However, equating this first order condition to the price ratio of fertilizer to rice (Px/Py) and solving for X provides the economic optimum level of fertilizer use which also maximizes yield, all other things being equal. This is because, by doing so, the solution equates the marginal product of X with the marginal cost of producing X, which is the condition for economic optimization under the assumption of perfect competition. The solution of optimum level of fertilizer (X\*) is given by:

$$\frac{dy}{dx} = \beta + 2\gamma X = Px / Py \qquad (3)$$
$$X^* = \frac{Px / Py - \beta}{2\gamma} \qquad (4)$$

#### 2.2 The empirical model

The model described in section 2.1 requires that except N fertilizer, all other inputs should remain constant. But the experimental data we received has variations in the dose of nitrogen as well as potassium and phosphate fertilizers. Therefore, we need to keep the framework but extend the model to accommodate variation in doses of potassium and phosphate fertilizers. Also, such extension provides a more realistic estimation of yield response of rice to N fertilizer while controlling for the use of other two main fertilizers, P and K. The extended quadratic model of the yield response function is given by:

$$Y = \alpha + \sum_{i=1}^{3} \beta_k X_i + \sum_{i=1}^{3} \sum_{k=1}^{3} \gamma_{ik} X_i X_k + \sum_{t=1}^{11} \sum_{l=1}^{15} \delta_{tl} T_t L_l + \varepsilon$$
(5)

where Y is the yield of rice, X is the active ingredient of fertilizer nutrients (i = 1, 2 and 3 where 1 = N (nitrogen), 2 = P (phosphorus) and 3 = K (potassium); T is the set of dummy variables to account for years (t = 2001 ... 2011); L is the set of dummy variables to account for locations of the experiments (1 = 1, .... 15);  $\alpha$ ,  $\beta$ ,  $\gamma$ , and  $\delta$  are the parameters to be estimated, and  $\epsilon$  is the error term.

The first order condition with respect to N provides:

$$\frac{dy}{dX_1} = \beta_1 + \gamma_{11} 2X_1 + \gamma_{12} X_2 + \gamma_{13} X_3 = 0$$
(6)

Equating this first order condition to the real price ratio of fertilizer to rice  $(Px_1/Py)$  and solving for X<sub>1</sub> provides the economic optimum level of N fertilizer use, all other things being equal. The solution of economic optimum N fertilizer  $(X_1^*)$  is given by:

The Bangladesh Journal of Agricultural Economics

$$\frac{dy}{dX_1} = \beta_1 + 2\gamma_{11}X_i + \gamma_{12}X_2 + \gamma_{13}X_3 = Px_1 / Py$$
(7)

$$X_{1}^{*} = \frac{Px_{1}/Py}{2\gamma_{11}} - \frac{1}{2\gamma_{11}}(\beta_{1} + \gamma_{12}X_{2} + \gamma_{13}X_{3})$$
(8)

First, we need to estimate Eq (7) to derive the economic optimum dose of N fertilizer on yields of HYV Aman, HYV Boro and HYV Aus, respectively. Next, using the optimum dose of N fertilizer as shown in Eq. (8), we simulate or explore two sets of questions: (a) what is the effect of real price changes of urea on the optimum level of N fertilizer use, keeping real price of rice constant; and (b) what is the effect of real price changes of urea on HYV rice yield. To obtain simulation results of change in optimum dose of N fertilizer in response to price change, we use Eq (8) by changing price ratios as required. To obtain an estimate of the effect on HYV rice yield (Y) due to change in optimum dose of N fertilizer in response to change in real price of urea fertilizer, we use the following formula:

$$\Delta Y = \beta_1 \left( X_1^f - X_1^i \right) + \gamma_{11} \left[ \left( X_1^f \right)^2 - \left( X_1^i \right)^2 \right] + \gamma_{12} \left( X_1^f - X_1^i \right) \overline{X}_2 + \gamma_{15} \left( X_1^f - X_1^i \right) \overline{X}_3$$
(9)

where  $X_1^{i}$  (the initial level before prices increased) and  $X_1^{f}$  (the final level after prices increased); the regression coefficients come from Eq. (7), and  $\overline{X}_2$  and  $\overline{X}_3$  represent the mean levels of the use of P and K fertilizers, respectively. All models were estimated by using the econometric software STATA Version 10 (StataCorp, 2007).

#### 2.3 Data and the variables

The BRRI experimental data on various HYV rice of Aus, Aman and Boro seasons were taken for a period of 11 years, i.e., 2001–2011. These experiments were conducted in various research stations of BRRI located in 15 regions, hence include wide variations in production environment and agroecology. Data include yield per hectare (kg) and corresponding doses of N, P and K fertilizers (BRRI annual reports, various issues). The price data of rice by season (Aus, Aman and Boro) and urea fertilizers for each corresponding year was taken from various issues of Bangladesh Statistical Yearbooks (BBS, various issues). The nominal price data were then converted into real price with 2011 as the base year. This exercise takes out the effect of inflation from the price data which is important in a nation like Bangladesh where inflation rate is very high. The final sample size stands at 887 HYV Aman rice, 919 HYV Boro rice, and 72 HYV Aus rice. The paucity of sample size of HYV Aus rice demonstrates the focus of research on the main two seasons of rice only, i.e., HYV Aman and HYV Boro rice by BRRI.

#### **III. RESULTS AND DISCUSSION**

Table A1 in the appendix presents the results of the parameter estimates of Eq (7) for HYV Aman, HYV Boro and HYV Aus models. All the regressions have good explanatory power. The F-statistic confirms that the use of these sets of variables significantly explains variation

in the level of HYV rice yield. The adjusted  $R^2$  values are estimated at 0.31 for HYV Aman rice, 0.40 for HYV Boro rice and 0.60 for HYV Aus rice, respectively. A number of locationtime dummy interaction variables are significantly different from zero, which justifies the need to control for locational and temporal variation in rice production. For example, the coefficient on the Gazipur, 2001 for HYV Aman rice is 1287.4 indicating that the average yield per hectare in Gazipur area in 2001 is 1287.4 kg higher than the mean yield of the total sample.

Table 4 presents the levels of N, P and K fertilizers used in the experiment stations to maximize HYV rice yield. The study also reports the estimated economic optimum level of N fertilizer  $(X_1^*)$  along with standard deviation. The table also reports a set of simulated response of optimum level of N fertilizer as the real price of urea changes, keeping real rice price constant. It present changes in optimum level of N fertilizer use in response to 10%, 20%, 30%, 40% and 50% increase in the real price of urea fertilizer. Finally, the last five rows show the effect of the changes in optimum level of N fertilizer on HYV rice yield.

Variables	HYV Ar	nan model	HYV B	oro model	HYV A	us model
- and the	Mean	Standard	Mean	Standard	Mean	Standard
		deviation		deviation		deviation
Experimental P (TSP)	11.18	2.18	20.71	6.04	13.43	5.05
Experimental K (MP)	40.71	6.56	51.88	12.31	44.93	10.60
Experimental N (Urea)	75.42	17.79	125.71	16.97	66.08	20.76
Optimum N	120.86	79.07	209.58	18.11	58.08	13.77
Optimum N (10% rise in urea	119.94	79.06	209.38	18.10	58.13	13.77
price)					8	
Optimum N (20% rise in urea	119.02	79.06	209.17	18.10	58.17	13.77
price)						10 70
Optimum N (30% rise in urea	118.10	79.05	208.97	18.10	58.22	13.78
price)						10.77
Optimum N (40% rise in urea	117.19	79.06	208.76	18.10	58.27	13.77
price)						10.77
Optimum N (50% rise in urea	116.27	79.05	208.56	18.10	58.32	13.77
price)					0.04	0.01
Yield effect (10% rise in urea	-19.74	22.13	-4.97	4.46	0.04	0.01
price)		a na 11 na jin		0.00	0.00	. 0.03
Yield effect (20% rise in urea	-39.78	44.29	-9.95	8.92	0.09	0.05
price)				10.00	0.15	0.04
Yield effect (30% rise in urea	-60.13	66.46	-14.93	13.38	0.15	0.04
price)		12 100 - 100 - 100 - 100			0.00	0.06
Yield effect (40% rise in urea	-80.77	88.66	-19.91	17.85	0.20	0.00
price)			2		0.00	0.07
Yield effect (50% rise in urea	-101.72	110.87	-24.90	22.31	0.26	0.07
price)	10 10 11 10 10 10 10					2

 

 Table 4. Simulation results of the economic optimum levels of N fertilizer use and effect on HYV rice yield in response to urea price change

It is clear from Table 4 that the economic optimum of N fertilizer use is much higher than the level of fertilizer used in experiments except for Aus rice where it is lower. For HYV Aman rice, the optimum level of N is 120.9 kg/ha whereas the use level in experiments is only 75.4 kg/ha along with 40.7 kg/ha of P and 11.18 kg/ha of K. In other words, the economic optimum level of urea fertilizer use is 60% higher than used in the experiments, implying that an additional 45.4 kg/ha is needed to maximize HYV Aman rice yield which is also economically optimum. Similarly, for HYV Boro rice, the optimum level of N fertilizer use is 67.2% higher than the dose used in the experiments, implying that an additional 83.9 kg/ha of *N is required. The scenario is exactly opposite with the case of HYV Aus rice. It should be* noted that the number of observations in Aus rice is too small (only 72), therefore, the results should be treated with caution. The optimum dose of N fertilizer is estimated at 58.1 kg/ha whereas the level used in the experiment station is much higher at 66.1 kg/ha implying that experiment stations are overusing N fertilizer in Aus rice and one can reduce urea fertilizer by 8.0 kg/ha.

Table 4 also shows that changes in real price of urea have notable reduction in optimum dose of N fertilizer for Aman rice only and minor effect on Boro and Aus rice. In case of Aman rice, a 50% rise in the price of urea will reduce optimum level of N fertilizer by 4.6 kg/ha or 3.8% reduction. This needs attention because Aman season provides the bulk of rice output of the country and movements in the price of urea fertilizer will have discernible effect on its optimum usage.

Finally, the study presents the effect on yield of HYV rice due to change in optimum doses of N fertilizer in response to movements in the price of urea fertilizer. The results show large scale reduction in the yield of Aman rice followed by moderate reduction on Boro rice but no effect on Aus rice. A 50% increase in the real price of urea will reduce HYV Aman rice yield by 101.7 kg/ha followed by Boro rice yield by 24.9 kg/ha. Once again, the rise in the urea price will exert detrimental effect on Aman rice crop, which is a matter of concern.

#### IV. CONCLUSION

The main objective of this study is to estimate the impact of urea price changes on the economic optimum level of N fertilizer use in HYV rice production and its yield for Aus, Aman and Boro seasons, respectively. The results revealed that the experimental level of N fertilizer use is far lower than the economically optimum level of N fertilizer for Aman and Boro seasons but higher for Aus season. The gap is highest for HYV Boro rice closely followed by Aman rice. An increase in real price of urea by 50% will exert a 3.8% reduction in optimum dose of N fertilizer in HYV rice cultivation in Aman season and reduce rice yield substantially by 101.2 kg from its existing level, which is a serious detrimental effect. The corresponding effect on HYV Boro rice is not so high but should not be ignored either. The effect of price change of N fertilizer on HYV Aus rice is negligible.

The present analysis demonstrates the detrimental effect of a reduction in fertilizer subsidy that will be exerted on the yield level of principal rice crop, i.e., HYV Aman rice, which provides the bulk of foodgrain supply for the nation. Therefore, price policy should be aimed

at controlling real and/or relative price of urea with respect to rice price. This can be achieved by either continuing to subsidize urea fertilizer or by increasing rice price or a combination of both. Mujeri *et al.* (2012) also concluded that subsidy on fertilizers needs to continue in Bangladesh in order to make crop production attractive and profitable.

#### REFERENCES

- Ahmed, R. 1978. Price support versus fertilizer subsidy for increasing riceproduction in Bangladesh. The Bangladesh Development Studies, 6 (2). 119–138.
- Ahmed, R. 2001. Retrospects and Prospects of the Rice Economy of Bangladesh. University Press Limited, Dhaka, Bangladesh.
- Barkat, A., R. Faridi, S. N. Wadood, S. K. Sengupta, S. N. M. E. Hoque 2010. A Quantitative analysis of fertilizer demand and subsidy policy in Bangladesh, National Food Policy Capacity Strengthening Programme, FAO, Bangladesh.
- Barker, R., Y. Hayami 1976. Price support versus input subsidy for food self-sufficiency in developing countries. American Journal of Agricultural Economics, 58 (4). 617–628
- Bayes, A. M., K. A. Parton, R. R. Piggott 1985. Combined price support and fertilizer subsidy policies for food self-sufficiency: A case study of rice in Bangladesh. Food Policy, 10 (3): 225-236.
- BBS 2001 & 2011. Statistical Yearbook of Bangladesh: 2001 to 2011. Bangladesh Bureau of Statistics, Ministry of Planning, GoB, Dhaka.
- BRRI 2001 & 2011. BRRI Annual Report: 2001 to 2011. Bangladesh Rice Research Institute, Gazipur, Bangladesh.
- Begum, A. A., B. Manos 2005. Impacts of fertilizer pricing policy in Bangladesh: A Multicriteria Analysis. Agricultura Tropica et Subtropica, 38(2). 6–18.
- FAOSTAT (variousissues). World Agricultural StatisticsDatabase, FAOSTAT. Food and Agricultural Organisation of the United Nations, Rome, Italy.<u>http://faostat3.fao.org/home/E</u>
- Islam, M. N., A. Ishida, K. Taniguchi 2007. Market reform and farmdemand for inorganicfertilizers in Bangladesh. International Journal of Agricultural Research, 2: 325-337.
- Jaim, W. M. H., S. Akter 2012. Seed, fertilizer and innovation in Bangladesh: Industry and policy issues for the future. Project Paper, International Food Policy Research Institute, Washington, D.C., USA.
- Kafiluddin, A., M. S. Islam 2008. Fertilizer distribution, subsidy, marketing, promotion and agronomicuseefficiency scenario in Bangladesh, IFA CrossroadsAsia-Pacific in Melbourne, International Fertilizer Industry Association (IFA), Melbourne, Australia.
- MoA 2014. Fertilizer subsidy for urea and non-urea fertilizers for the past five years (2008/09 2012/23). Ministry of Agriculture, Government of Bangladesh.
- MoA 2013. National Agricultural Policy-2013. Ministry of Agriculture, Government of Bangladesh.
- Mujeri, M. K., S. Shahana, T. T. Chowdhury, K. T. Haider 2012. Improving the effectiveness, efficiency and sustainability of fertilizer use in South Asia. Policy Research Paper, Global Development Network, New Delhi, India.
- Rahman, S. 2010. Six decades of agricultural land use change in Bangladesh: effects on crop diversity, productivity, food availability and the environment, 1948-2006. Singapore Journal of Tropical Geography, 31(2): 254-269.
- Rahman, S., M. M. H. Kazal 2015. Determinants of Crop Diversity in the Regions of Bangladesh (1990-2008). Singapore Journal of Tropical Geography. 36 (1): 83-97.
- Renfro, R. Z. H 1992. Fertilizer price and subsidy policies In Bangladesh. World Development, 20(3): 437-455.
- Stata Corp 2007. Stata Version 10. Stata Press Publications, College Station, Texas, USA.
- Zahir, S. 2001. BIDS. Impact of reforms in agricultural input markets on crop sector profitability in Bangladesh. @ http://www.saprin.org/bangladesh/research/ban\_agri\_input.pdf.

Variables	HYV Ama	n model	HYV Bo	ro model	HYV Au	s model
	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Constant	656.7418	0.69	5688.2540***	4.91	4199.0780	0.21
N	51.0808***	3.39	-23.7173	-1.50	34.9487	0.05
P	-73,1019*	-1.69	-181.8295	-1.42	0.0000	0.00
К	9.7920	0.56	12.3207	0.53	0.0000	0.00
N*N	-0,1743***	-3.05	-0.0449	-0.82	0.9232	1.06
р*р	-0.6897	-0.9	-3.2253	-1.08	15.5786*	1.65
K*K	0.0303	0.22	0.0003	0	1.4079	0.14
N*P	1.0502***	3.30	3.2709***	3.82	-5.8670	=0.79
N*K	0.0182	0.14	-0.0289	-0.16	-1.3915	-0.08
P*K	-0.8032*	-1.75	-0.3560	-0.21	-6.8435	-0.37
Time-location du	mmy variables	C				
Gazipur2001	1287.4030***	3.56	-356,2755	-0.83	-103.3333	=0,1
Gazipur2002	1764.1950***	4.74	-546.9726	-1,01	-500.0000	-0.47
Gazipur2003	1040.9130**	2.14	18.9784	0,05		
Gazipur2004	101017120	2	-837.9062**	-2.14		
Gazipur2005	1287.0570***	3.13	-278.9436	=0.84	230,0000	0.29
Gazipur2006	514.1336	1.55	-936.1234***	-3,22	-370,0000	=0.46
Gazipur2007	864.1081**	1.99	-455.6468	=1.51		
Gazinur2008	490.9231	1.36	-568.3145*	=1.80	930,0000	0.82
Gazipur2009	610.3704*	1.65	-806.8659**	-2.35		
Gazipur2010	107.0118	0.31	-822.8898***	-2.66	975.0000*	1.64
Gazipur2011	991.8527***	2.66	-394,4944	-1.18	469,4950	0.45
Comilla2001	2456.0510**	2.54	-1287.4100**	-2.68		
Comilla2002	Electoric		462.5902	0.75		
Comilla2003	1935.7670***	4.23	-143.7468	-0.27		
Comilla2004	1946 6860***	3.17	1 1011 100			
Comilla2004	1664 1860***	3.00				
Comilla2005	307 4484	0.01	-724.1204**	-2.17	-120.0000	=0.15
Comilla2000	\$26 0505	0.55	312.5902	0.50		
Comilla2007	1130 8880***	2 60	-378.4998	-0.78		
Camilla2000	371 7350	0.61	-\$0\$ 01\$1	-1.21		
Comilla2009	1377 3470	1 43	150 7361	0.40		
Comilla3011	19971:2470	1:49	-\$67 7638	-1 18		
Commazori Habigani3003	1144 9050	1 50	-90111020	-1110		
Habiganj2003	660 8780	1.99	-349 0117	-0.66		
Habiganj2000	000.0/09 733 6635*	1.19	-197 4008	-00.00 E A-		
Habiganj2007	124:9023	3.63	413 5003	-9:3		
Habigani2000	1/04:3/80	3:04	412.3902	6.9		
Habiganj2009	1934.0920	4:09	468 8165	0.75		
Habiganj2010	1999.1130	3.20	408.019/	9.73		
Habiganj2011	3234.1530	0.23	661 A56A	.1.88	100 6313	A 18
Kushtla2001			=031.0309	-1.22	=199.0212	=0:19
Kushtia2003	1 100		552.5902	0.00		
Kushtia2006	1499.6750***	3.35	535.7795	1.11		

Appendix Table A1. Yield response function of HYV rice using BRRI experimental data (2001-2011)

Appendix Table A1. Continued...

Variables	HYV Aman	model	HYV Bo	ro model	HYV Au	s model
T AT INDIES	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Kushtia2008	550,9361	1.12	-927.9656**	-2.36	-746.7424	-0.66
Kushtia2009			-1177.8800**	-1.96	-1020.0000	-1.26
Kushtia2010	-0,4495	0	24,6196	0.05		
Kushtia2011	1823.3790**	2.54	45,9235	0.09		
Raishahi2002			-287.4098	-0.46		
Raishahi2003			-1201.5540***	-2.95		
Raishahi2006	430,3131	0.77	231.2007	0.74	-1243.3330 <sup>*</sup>	-1.89
Raishahi2007	2453.5060***	5,66	886.7385	1.41		
Raishahi2008	492,2472	0.88	-843,4998	-1.36		
Raishahi2009					-12.3409	-0.01
Raishahi2010	422,7306	1.01	53.8197	0.09		÷.,
Raishahi2011	701.8563	1,49	-448,9942	-1.30		
Khulna03	252.4857	0,64	895.3976***	2.69		
Khulna04	1301.7630***	2.87	1133,5090***	2.67		
Khulna06	424.1526	0.82	-490.4501	-1.53		
Khulna07	1443.9140**	2.34				
Khulna08	1743.7340***	4.78	-1186.2740***	-2.91		
Khulna00	=678.3511	-1.57	562.5902	1.17		
Khulnalû	777.0643	1.05	=136.5089	=0.45		
Khulnal 1	268 2863	0.78	33.8601	0.11		
Barleal2002	-00 8875	=0.16	503.7112	1.28		
Barical2002	1490 4840**	2 07	-870,1276***	=2.92		
Barical2003	2085 1860***	415	erensie	2.92		
Barical2004	1668 7370***	3 44	12.7880	0.03		
Barleal2000	1136 0510	1 18	I ETTODO	0105		
Barles 13009	1330 0030***	3.33				
Barisal2000	1345 7560**	3.22	363 5003	0 58		
Barisal2009	1543.7300	2,41	670 3568	1 28		
Barisal2010	1310.7020	4:9 0 6 5	45 5137	0.15		
Barisal 2011	229:0197	0.09	1137 8800	-135		
Chittagonguo	#30 #38#	6 74	1363 \$000*	-1.99		
Chittagong IV	=949,9309	=0,74	1302.3900	-3 10		
Tangalluo			=1/04:2400 40 3533	-9:19		
Tangalius	= 13 6136	1.21	40,2333	0.09		
Tangaillo	743.9139	1.41	2/3:0492	0.34		
Tangailli	277.2472	0.39	1200 4100**	3 46		
Dinajpur05			=1208.4100	=4:49		
Dinajpur06	140 4615		023.3701	1:20		
Dinajpur09	140.4615	0.2	35 6 4 6 3	8 88		
Dinajpur10	405.6151	. 0.72	75.0492	0.09	1463 3548	1 35
Feni02	-338.2001	=0.67	=1117.5820	=2.09	=1462.7940	=1.33
Feni03			=267,4098	=0.60		
Feni04		an Magazina	8.0928	0.02		
Feni06	-876.6211	=1.22	828.0847	0.99		
Feni07			71.6223	0.21		
Feni08			=276.7472	=0.57		
Feni09			=637,4098	=1.03		

The Bangladesh Journal of Agricultural Economics

Appendix Table A1. Continued...

Variables	HYV Ama	n model	HYV B	Boro model	HYV A	us model
$(\gamma^{*},\gamma^{*}) = (\beta^{*},\beta^{*})$	Coefficient	t-ratio	Coefficient	t-ratio	Coefficien	t t-ratio
Feni10	and the second second		-71.4099	-0.16		1 40.00
Fenil 1	2173.3790***	3.02	-234.2334	-0.44		
Rangpur02	1146.0510	1.19				
Rangpur03	1103.9140**	2.24	-504.5927	-1.38		
Rangpur04	2359.8410***	3.46				16.
Rangpur06	-26.6211	-0.04	-1244.6630**	-2.00		
Rangpur07			1037.5900**	2.16		
Rangpur08	625.5806	1.50				
Rangpur09	179.9853	0.37				
Rangpur10	697.6483	1.47	-452.1612	-1.00		
Rangpur11	1808.3790**	2.52	22.3549	0.06		i de la composición d
Bhanga03	1719.9170**	2.39				
Bhanga05	1182.5190*	1.77				
Bhanga06	2074.6680***	3.37	-419.6626	-0.67		
Bhanga07	1150.3150**	2.22	the second s			
Bhanga08	2898.9450***	6.37	627.2245*	1.64		
Bhanga09	3308.8360***	7.97	757.5126*	1.69		
Bhanga10	1612.7230***	2.62	275.0492	0.42		
Bhangal 1	2120.1530***	4.09		E E E E E E E E E		
Mymensingh06	-14.1211	-0.03	-541.9125	-1.13		
Mymensingh07			-87.4099	-0.14		
Mymensingh08			-957.5130**	-2.13		
Mymensingh10	645.1641	1.22	755.0492	0.88		
Mymensingh11	1528.3790**	2.13				2018
Jessore06	115.8789	0.21	-650.9151	-1.44		
Jessore10	1177.2470	1.22				
Jessore11	2564.6680***	4.16				
Bogra07	×		-237,4098	-0.49		AN STREET
Sylhet2009			14		-245.0838	-0.22
Model			the test			0.22
diagnostics						
Adjusted $R^2$	0.31		. 0.43		0.60	
F statistic	5.28***		8 56***		5.86***	
Sample size	884	1.16	918		200	

# 76