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Market Reform and Farm Demand for Inorganic Fertilizers in Bangladesh

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Abstract: The underpin issues of the study are to examine the farm level inorganic fertilizers (urea, TSP and MP known as primary plant nutrients) use, their determinants and suggest policy remark(s) at new circumstances of policy reform in inorganic fertilizers market in Bangladesh. The findings of the study reveal that the farmers were using excessive urea and comparatively fewer amounts of TSP and MP and those farmers were using comparatively more TSP and MP, in contrast they were using less amount of urea. The estimated results of determinant functions indicate that the use of TSP and MP at the farm level could be increased by reducing their prices and increasing the urea price at the farm level, simultaneously. Side by side, massive extension program regarding the balance fertilizers use could also increase the use of these two fertilizers at farm level and the use of better combination of TSP and MP alone with urea might reduce the tendency of using more urea. The mean of reducing prices of TSP and MP at farm level is to provide price subsidy in the country. To overcome the budgetary constrain, government of Bangladesh could increase the urea price and earn extra revenue. And this extra revenue earned from urea sale could be provided as price subsidy for TSP and MP in the country.

Key words: Inorganic fertilizers, urea, Triple Super Phosphate (TSP), Mureate of Potash (MP), determinant, Bangladesh

INTRODUCTION

The introduction of inorganic fertilizers at crop production in Bangladesh is known to date back to the early 1960s. Three primary plant nutrients, Nitrogen (N), Phosphorus (P) and Potash (K), are being supplied from urea, Triple Super Phosphate (TSP) and Mureate of Potash (MP) fertilizers to the soils of Bangladesh for more than three decades. The effect of these three fertilizers on crop production has been demonstrated during the last three decades and policy focus on fertilizers largely dealt with these three types of fertilizers. It was well established that after the fertilizers market reform the use of urea has increased but the use of TSP and MP have drastically decreased. In this contest, Bangladesh soils would seriously be eroded, resulting in total decline of crop production in future. So, the present thrust is to rationalize the use of these three types of fertilizer at the farm level in the country. Moreover, any study considering total inorganic fertilizers use must be biased and inconsistent in the light of real situation prevailing in the country.

A series of recent studies on the factors determining farm demand for inorganic fertilizer by (Abdoulaye and Sanders, 2005; Coady 1995; Croppenstedt and Demeke, 1996; Minot *et al*., 2000) are based on the total fertilizers use considering single crop using single equation model. Rahman (2003) analyzed the factors determining of farm demand for pesticide used in Bangladesh using the same single

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equation model but considered all the crop enterprises of sample farms. Further more, the previous farm level studies (Khan, 1981; Ahmed, 1981; Hossain, 1981) for inorganic fertilizers demand in Bangladesh were before the effect of market reform and considered the total fertilizers use in the country in regard to the HYV rice production. As because, initially only HYV rice was been fertilized in the country. But, at present, farmers are using more or less inorganic fertilizers for all crops at their farms and the farms of Bangladesh are multi crop enterprises producing farms. All crop enterprise(s) in a farm is competing for inorganic fertilizers. Hence, the farm level inorganic fertilizers use depends on the combined effect of all crop enterprise(s) of a farm rather than single crop in Bangladesh. So, it would be very rational to include all the crop enterprises at farm level competing for inorganic fertilizers and analyze the determining factors of demand for deferent types of inorganic fertilizers at the farm level in the country. Therewithal, a study yet to be taken in new circumstances of policy reform for inorganic fertilizers uses covering the whole farm crop enterprise(s) in the country. Therefore, it is important to study the use of urea, TSP and MP fertilizers at the farm level and evaluate carefully the determinants of these fertilizers use at the farm level for policy recommendation(s) in the country.

Market Reform and National Level Use of Inorganic Fertilizers

At the initial stage, the urea, TSP and MP were highly subsidized and public agency was solely responsible for procuring and distributing the fertilizers through out the country. The subsidy backed price policy for fertilizers often blamed for irrational uses, insignificant incentives, non-cost effective procedure and budgetary constraints for subsidizing at a high amount by the government of Bangladesh (Osmani and Quasem, 1990). As a result, structural adjustment policies (SAP) were implemented for privatization and deregulation of fertilizers market since 1978 and ended in the year 1992 with the removal of subsidy (a chronology of policy reforms towards liberalizing the inorganic fertilizers market in Bangladesh is presented in Appendix 1). Then, it was assumed that the removal of fertilizer subsidy would continue to benefit the government of Bangladesh by reducing expenditures, but, more importantly, it would promote a better allocation of resources and, in the long run, would contribute to a more efficient and productive agriculture (Baanante *et al*., 1993). But recent time series studies at the national level by the authors (Islam *et al*., 2006a, b) found that after the impact of SAP, fertilizers procurement and distribution by private sector was counter productive especially for TSP and MP rather than urea. After the fertilizers market reform, urea production, procurement and pricing in the country still remain on the shoulder of public sector; urea price is relatively cheaper than other fertilizers; per hectare consumption of TSP and MP have reduced drastically and prices of these fertilizers rise sharply in the country. To the extent that the per hectare consumption of different types of inorganic fertilizers at the national level have increased smoothly up to 1990-91. After the market reform, per hectare consumption of urea increased sharply and the total fertilizers consumption within this period has also increased due to sharp rise in urea consumption in the country. In contrast, the per hectare consumption of other two fertilizers TSP and MP have decreased in the country (Fig. 1). But the use of TSP and MP should be increased subsequently with urea. Thus, it excavates that the farmers of Bangladesh are not using balance doses of inorganic fertilizers rather use more urea compared to TSP and MP. In this contest, Bangladesh soils would seriously be eroded, resulting in total decline of crop production in future. Under such situation, Karim *et al*. (1989) explained that the Liebig's Law of the Minimum would operate in Bangladesh agriculture, which states that if one of the nutritive elements is deficient or lacking, plant will be poor even when all the other elements are abundant. It is plausible that the crop yield will increase considerably with the balance application of NPK fertilizers.

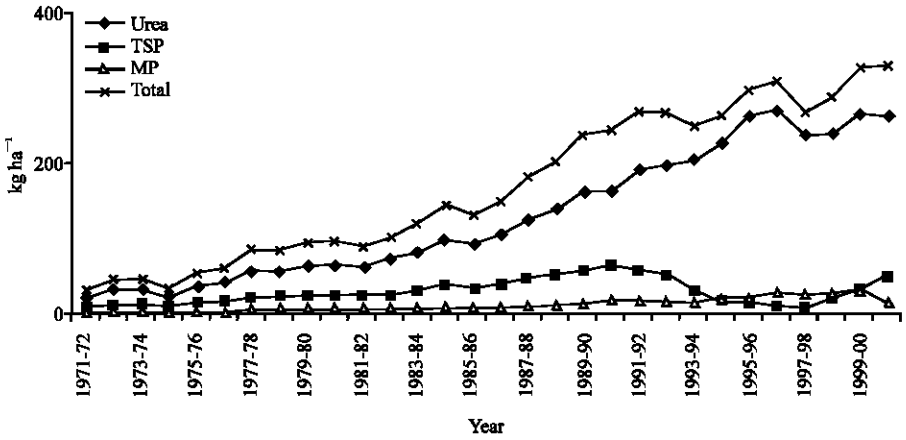

Fig. 1: Per hectare inorganic fertilizers consumption scenario in Bangladesh. Data Source: Islam *et al.* (2006b)

MATERIALS AND METHODS

Region and Survey

The study is based on farm-level cross-section data from three districts of Bangladesh out of 64 districts. The districts were selected on the basis of cropping intensity and three top most cropping intensity districts (namely Bogra, Rangpur and Jamalpur, respectively) were chosen with the help Yearbook of Agricultural Statistics of Bangladesh, 2001 for the year 1999-2000; assuming these districts would be technologically advanced. So, the findings would be applicable for the whole country equally. Then, from the each district, one thana (sub-districts) is selected randomly. From the each thana, two side by side villages were selected and from the each village 50 farmers were interviewed randomly with pre-designed questionnaires. Finally, the total of 100 sample farmers from each district consist a total number of (100×3=) 300 sample farmers from the three districts (location of study area is shown in Fig. 2). Farm interviews were conducted from December 22, 2005 to January 28, 2006 covering the cropping season October, 2004 to September 2005. Survey data for each respondent included age, schooling and occupation of household head, farm size, family composition, income source, details of input-output data and information on infrastructural facilities, etc.

Econometric Model- Determinants of Farm Level Fertilizer (s) Use

Estimation of single equation in cross section data analysis is the easiest and most popular way for estimating the determinants of input demand (used by Abdoulaye and Sanders, 2005; Coady 1995; Croppenstedt and Demeke, 1996; Minot *et al*., 2000; Rahman, 2003). A farm level demand for an input is depend on the level of the prices of the various inputs used in crop production. Although the objective is to measure the demand function for different types of fertilizers uses at farm level, the approach must be grounded at the farm level profit maximizing behavior of farmers for a single crop. So, a production function for a typical farm is considered as follows:

$$Y = AF^{\alpha}L^{\beta};Z_i \quad (1)$$

Where, Y is output and F is fertilizer input and L is another input of production. Z represents the fixed inputs and other shifter variables of the function. Conventionally, fixed costs are ignored. Thus the profit function is:

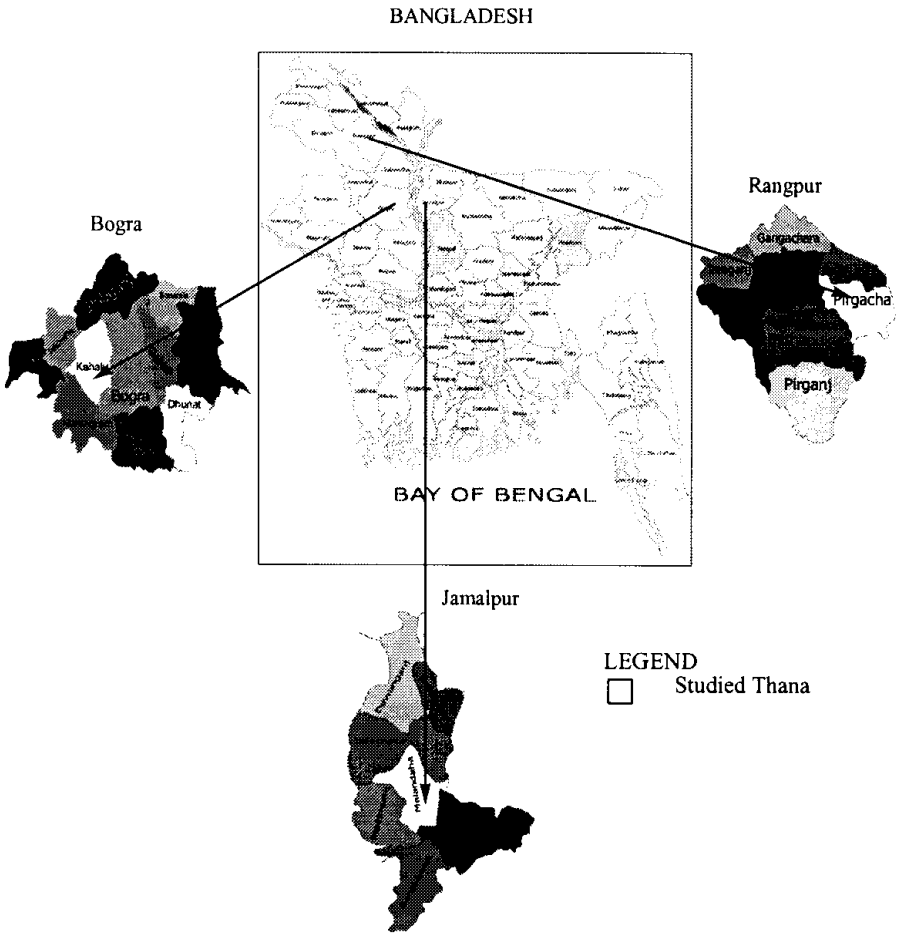

Fig. 2: Map of Bangladesh and Location of the studied area. Source: derived from www.aitlbd.net/bangladesh/mapsb; dated: 05-09-2006

$$\Pi = P.Y - P_1F - P_2L = P.(AF^{\alpha}L^{\beta}) - P_1F - P_2L \quad (2)$$

Where, P is output price, P_1 is price of fertilizer and P_2 is price of another input L.

Finally, considering necessary condition for profit maximization and using derivative property (for details see Mahmood, 1995), the derived input demand function is,

$$F = f(P_1/P, P_2/P) \quad (3)$$

The Eq. 3 is double-log form and input prices are relative to output price, while a linear form of this equation also could be derived using a generalized quadric specification of a profit function (Mergos and Stoforos, 1997). Therefore, the determinants of different types of inorganic fertilizers use functions at farm level are the relative inputs prices regarded to weighted output price (total gross return from all crops grown at farm level divided by the quantity of all crops grown) and a set of exogenous factors. In a number of recent studies explaining fertilizer adoption (Abdoulaye and Sanders, 2005; Coady, 1995; Croppenstedt and Demeke, 1996; Minot *et al*., 2000), beside usual price factors,

an emphasis is given to access to markets, farm and farmer characteristics and liquidity/credit. Thus, Determinants of household level inorganic fertilizers use include (1) the relative price of inorganic fertilizers, (2) some other relative inputs prices, (3) access to market or market orientation, (4) type of farm, whether the farm is own operated or not, (5) other source of income, (6) communication with extension personnel, (7) infrastructure development, (8) age of the household head, (9) schooling of household head and (10) regional dummy variable(s).

RESULTS AND DISCUSSION

Basic Characteristics of the Study Area

The soils of Bangladesh are classified into three broad categories- floodplain soils, hill soils and terrace soils. The study area belongs to the floodplain soils, mainly developed by the silt depreciation. The soil of Bogra and Japamlpur were developed by the silt of the river Brahmaputra and the soils of Rangpur were developed by the silt of the river Tista. The floodplain soils comprise 79% of total land area (BBS 2001) and suitable for cultivation of most of the crops year round. Bogra is situated 229 km in the northwest from the capital of Dhaka by road and located within Kahalu thana (sub-district) on the west of district head quarter of Bogra. Rangpur is 335 km in the north of the capital Dhaka by road and located in the Pirgacha thana (sub-district), estern part of Rangpur district. Jamalpur is 155 km in the northwest of the capital Dhaka and located in the Melandaha thana (sub-district), centre part of Jamalpur district.

The study reveals that the main livelihood activity of sample farmers was agriculture and on an average more than 90% of sample farmers' main occupation was found to be agriculture in the study area. The cropping intensities were found to be 203, 199 and 193% for Bogra, Rangpur and Jamalpur, respectively and were also higher than the national average of 175% for the year 1999-2000 BBS, 2001). Different types of field crops are grown in the study area, among them rice is common field crop grown by each sample farmers. In the study area, more than 80% of total cropped area is covered by the HYV rice (HYV Aman and HYV Boro) and it was more than 81% for all food grains. The area under other crops were found to be 31%, the highest for the area of Rangpur followed by Bogra and Jamalpur by 15 and 6%, respectively. And the farmers of Rangpur were more market oriented compared to the farmers of Bogra and Jamalpur (Table 1).

Farm Level Inorganic Fertilizers Use

It was also found from the study that farmers are using more or less fertilizers for all field crops grown in the study area. Among these fertilizers, the primary plant nutrients (urea, TSP and MP) consist about 99% of total fertilizer use at farm level and secondary plant nutrients (gypsum and zinc) have very insignificant use (1% of total fertilizer use) in the study area. And on an average, urea alone covered more than 59% of total fertilizer use at farm level in the study area followed by TSP and MP by 24 and 15%, respectively. The ratio of urea, TSP and MP used at farm level for Bogra, Rangpur and Jamalpur were 4.08: 1.61:1, 2.53:1.36:1and 7.52: 2.32:1, respectively. It indicates that the farmers of Rangpur were using comparatively fewer amounts of urea and more amounts of TSP and MP followed by Bogra and Jamalpur districts (Table 1). It also found from the table that the farms of Rangpur was more market oriented i.e., more commercial (71%) compared to 63 and 59% for Bogra and Jamalpur, respectively. Therefore, the study reveals that the farmers who were using less amount of urea at their farm, alternatively, they were using more amounts of TSP and MP at their farm and market oriented farm was using better combination of inorganic fertilizers than the less market oriented farms. Moreover, it was found from the Table 2 that the share of urea at the farm level was the highest

Table 1: Some basic information of the study area

Items	Bogra	Rangpur	Jamalpur	All average
Age of household head	42.97	40.43	39.48	40.96
Schooling of Household head	4.05	5.18	5.02	4.75
Agriculture as main occupation (%)	99	94	90	94
Operational holding per farm	0.685	0.871	0.676	0.743
Total Cropped area (TCA) per farm	1.391	1.733	1.305	1.471
Cropping intensity (%)	203	198	193	198
Area under different crops per farm				
Food grains				
HYV aman rice	0.570 (41.56)	0.575 (33.25)	0.619 (47.52)	0.587(40.06)
HYV boro rice	0.581 (42.30)	0.603 (34.89)	0.603 (46.27)	0.595(40.61)
Wheat	0.020 (1.50)	0.0.21 (1.24)	0.006 (0.43)	0.011 (0.75)
Total	1.171 (85)	1.199 (69)	1.228 (94)	1.193 (81)
Other crops				
Potato	0.071 (5.16)	0.270 (15.62)	0.041 (3.17)	0.128 (8.78)
Vegetables	0.099 (7.25)	0.176 (10.19)	0.010 (0.78)	0.096 (6.52)
Spices	0.025 (1.82)	0.011 (0.67)	0.002 (0.22)	0.013 (0.88)
Others	0.023 (1.72)	0.076 (4.38)	0.021 (1.71)	0.04 (2.76)
Total	0.219 (15)	0.533 (31)	0.076 (6)	0.277 (19)
Inorganic fertilizers use per farm				
Urea	304.04 (60.32)	289.48 (50.97)	282.61 (68.97)	292.04 (59.13)
TSP	120.46 (23.90)	155.26 (27..34)	87.05 (21.24)	120.92 (24.48)
MP	74.59 (14.80)	114.16 (20.10)	37.58 (9.17)	75.44 (15.27)
Others (Gypsum and Zinc)	4.97 (0.99)	9.01 (1.59)	2.53 (0.62)	5.50 (1.11)
Total fertilizers	504.06	567.91	409.77	493.91
Market orientation				
HYV aman rice	48	50	49	49
HYV boro rice	64	71	51	62
Other crops	88	93	78	87
Total	67	71	59	65

Source: Field survey, 2006; Note: Figures in the parentheses are the share of total cropped area and share of total fertilizers use per farm in percentage, respectively

Table 2: Share of urea and other fertilizers (TSP and MP) of total fertilizers used for different crops grown at farm level in the study area (in%)

	Bogra			Rangpur			Jamalpur			All area average		
Crops	Urea	TSP	MP	Urea	TSP	MP	Urea	TSP	MP	Urea	TSP	MP
Food grains												
HYV aman	19.25	1.46	0.80	14.25	3.95	2.43	25.96	2.54	0.80	19.2	2.71	1.42
HYV boro	28.42	11.5	7.40	19.47	9.36	5.63	36.95	14.93	7.21	27.4	11.6	6.67
Wheat	0.12	0.05	0.02	0.39	0.23	0.10	0.19	0.06	0.02	0.24	0.11	0.06
Total	47.79	12.96	8.22	34.11	13.54	8.16	63.10	17.53	8.03	46.8	14.44	8.15
Other crops												
Potato	4.09	3.80	2.96	7.86	7.71	7.66	2.44	2.37	1.23	5.09	4.90	4.28
Vegetables	6.41	5.84	3.42	6.91	4.95	3.33	0.55	0.54	0.18	4.97	4.03	2.48
Spices	1.34	0.92	0.58	0.16	0.11	0.09	0.10	0.04	0.02	1.64	1.11	0.72
Other non-cereals	0.49	0.12	0.08	1.65	1.11	1.01	1.68	1.41	0.47	1.25	0.78	0.54
Total	12.33	10.68	7.04	16.58	13.88	12.09	4.77	4.36	1.90	12.95	10.01	8.02

Source: field survey, 2006

for all crops in the study area followed by TSP and MP. The share of urea of total fertilizers use for growing HYV rice was about 47%, whereas share of other primary plant nutrients (sum of TSP and MP) was found to be 22%. Thus, 80% share of total cropped area for HYV rice consumed 69% primary nutrients (urea, TSP and MP) of total fertilizers and 19% share of total cropped area for others crops consumed 30% primary nutrients of total fertilizers at farm level. These findings imply that fertilizers use at the farm level mostly dominated by the rice crop in the study area.

Use Rate of Inorganic Fertilizers for Growing Some Major Crops

Agriculture practice in Bangladesh is rice dominant and 75% of total cropped area is under rice production (BBS, 2001) and alone rice consumed 85% of total fertilizer used in the country (cited in Akteruzzaman and Jaim, 1999). So, the fertilizers use rate in per hector for rice production would significantly affect the total fertilizer used in the country. From the Table 3 it was found that the sample farmers were using excessive urea and using fewer quantities of TSP and MP in per hectare of land than the recommendation doses for growing HYV rice (HYV Aman and HYV Boro) in the study area. Incase of per hectare HYV Aman rice production; urea use is on an average 51% (59, 31 and 62% higher for Bogra, Rangpur and Jamalpur, respectively) higher than the recommended dose of Urea. And incase of HYV Boro it is 37% higher (46, 18 and 48% higher for Bogra, Rangpur and Jamalpur, respectively) than the recommended dose of urea. Hossain *et al.* (2003) also explained that the farmers of Bangladesh prefer to use more urea, because of quick response. On the other hand, the per hectare of TSP and MP use for HYV Aman are found to be 74 and 63% lower than the recommended doses, respectively and these are 26 and 16% lower for HYV Boro than the recommended doses. So, the respondent farmers were using excessive urea and fewer amounts of TSP and MP for growing HYV rice at the farm level. On the other hand, the ratio of urea, TSP and MP applied in per hectare of land for wheat are found to be 4.94: 2.2: 1, 3.64: 2.24: 1, 8.45: 2.60: 1 and 2.08: 0.93: 1 for Bogra, Rangpur, Jamalpur and recommended doses, respectively. In the case of potato, these ratios are 1.66: 1.16: 1, 1.23: 1.01: 1, 2.02: 1.82: 1 and 1.2: 0.8: 1 for Bogra, Rangpur, Jamalpur and recommended doses, respectively (Table 3). These indicate that the respondent farmers were also using proportionately excessive urea compared to TSP and MP in per hectare of land for growing wheat and potato than the recommended doses in the study area. Thus, it might be concluded that the farmers were using excessive amount of urea compared to TSP and MP for growing crops in the study area and not following recommended doses.

Determinants Inorganic Fertilizers Use

As mentioned earlier, the focus of this study is on the use of urea, TSP and MP at farm level and for convenience of analysis, two different functions will be derived (1) determinants of quantity of urea use and (2) determinants of quantity of other fertilizer use (aggregate amount of TSP and MP) at farm level.

Hence, the following specification for the inorganic fertilizers demand functions are, then obtain:

$$U \text{ or } O = f(P_u, P_O, P_L, P_P, OE, MO, OW, CE, IF, OS, AH, SH, RD, JD) \quad (4)$$

Where, dependent variables U and O are the amount of urea and aggregate amount of TSP and MP used in per hectare of operating holding at each farm level, respectively (kg ha^{-1}). Explanatory variables are farm level: P_U weighted price of urea (Tk kg^{-1})/output price (Tk kg^{-1}), P_O is weighted price of TSP and

Table 3: Applied fertilizers doses for some major crops grown in the study area (in kg ha^{-1})

	Bogra			Rangpur			Jamalpur			Average recommended doses[A]		
Crops	Urea	TSP	MP	Urea	TSP	MP	Urea	TSP	MP	Urea	TSP	MP
Food Grain												
HYV Aman	173.67	13.20	7.19	142.76	39.62	24.38	176.55	17.27	5.44	109	89	33
HYV Boro	253.22	102.21	51.97	185.93	104.39	56.80	258.37	89.34	41.39	174	133	67
Wheat	103.82	46.21	21.00	100.15	61.52	27.47	137.61	42.34	16.27	173	78	83
Potato	290.59	202.04	174.29	195.59	160.20	159.19	252.08	228.52	124.89	300	200	250

Source: Field Survey 2006; [A] Recommended fertilizers doses are moderate doses for moderate yields. Computed from MOA (2004) for rice; incase of wheat, it was Karim *et al.* (1989) and for potato it was Barman and Islam (2005)

MP (Tk kg^{-1})/output price (Tk kg^{-1}), P_L is price of labor (Tk/man-day)/output price (Tk kg^{-1}) and P_P is the weighted price of pesticide use (Tk/100 mL or g)/output price (Tk kg^{-1}). These are the four inputs that are essential in producing any crop and contributing significantly to the total cost of production and all these inputs prices are relative to output price. The farmers of Bangladesh are expected to respond and/or adjust their input levels to changes in the prices of these inputs. OE is the other economic activity variable has value 1 for farm in which the household member(s) has other source of income than crop production and otherwise is zero. The other source of income includes the remittance (migrating family members send or bring back remittances), small business, services, day-labors, carpenters, construction workers, dairy raising and fish culture etc. It expressed the liquidity

level or cash-flow issue of the farm household and indicating the cash available to the household for purchasing the inputs. Do those with the prospects of investing their capital in these activities put more or less money into fertilization compared with farmers who do not engage in other economic activities? MO is market orientation variable expressed in per cent. It was measured by summing up marketed surplus and marketable surplus of all crops in monitory term divided by the sum of gross return of all crops produced at each farm level. It measures the accessibility of each farm in the market. Farmers with greater market orientation generally more informed about market and crop management because of their frequent contacts with traders, other farmers and related peoples through market. The market orientation variable was expected to pick up some of the information effects in the model. It also served as a proxy of liquidity variable or capabilities of invest in fertilizers in some extent. OW is the dummy variable for own operated farm. If the type of farm is own operated then 1 and for tenant operated or owner cum tenant operated farm it is zero. It was assumed that own operated farm would behave rationally for fertilizers use rather than tenant or owner cum tenant operated farm. CE is the dummy variable for the farmers who have the communication with extension workers, is 1 otherwise 0. In the rural area, agricultural extension workers both from government and non-organization provide crop management training or advice. So, it was assumed that the farmers those who have communication with extension worker might have better management of inorganic fertilizers at the farm level. OS is the share of other fertilizers of total inorganic fertilizers used at the farm level. The earlier findings (Table 1 and 2) suggest that if the farmers use more amounts of other fertilizers, in contrast they use fewer amount of urea. To capture the effect other fertilizers use on urea use at the farm level, OS variable was included in the determinant function of urea and assumed to be negatively significant. IF is used as the index for development of infrastructure. The state of infrastructure, in terms of better transportation and marketing facilities would affect prices of fertilizers through transportation cost, profit margins of traders and availability of the inorganic fertilizers at right time. The prices farmers pay for inputs and receive for outputs include this transportation cost, trader's margin might vary across farms and regions, depending on the state of development of infrastructure. This effect was captured by the infrastructure index and the distance of fertilizer market, distance of paved road and distance of thana (sub-district) headquarter were considered in building the infrastructure index. Higher value of index indicates the low level of development of the area. AH is the age of household head and the SH is the schooling of household head. And RD is the area dummy for Rangpur district and JD is the dummy variable for Jamalpur district. The regional dummy variables indicate that there are important regional effects not being picked up by the other variables. The main limitations of this study are that soil fertility status was not examined and the risk variable is not considered in the econometric model of determinant function for inorganic fertilizer use. Thus, these two equations were estimated jointly assuming there might have simultaneous effect on each other and the estimated coefficients were not different from the coefficients of the two equation estimated separately, as because the most of the explanatory variables are the same (Gujarati, 1995).

As all the farmers in the study area were found to use urea for growing all of their field crops, OLS method was use to estimate the determinant function for urea. On the other hand, it was found from the study that some farmers were found not using TSP or MP in their crop fields. Theoretically, the application of usual continuous techniques (e.g., ordinary least square) in this setting might result in biased and inconsistent estimates since dependent variable is censored at zero. So, estimation of determinant function for other fertilizers (TSP and MP) was Tobit. Further more these two equations were estimated jointly and the findings of the determinant functions were presented in the Table 4. The models were checked for multicollinearity and the multicollinearity among the explanatory variables was not found sever. In the case of determinants for urea, coefficient of the ratio of pesticide price among all other ratio of input prices found to be negatively significant ($p< 0.01$); i.e., pesticide is competing with the use of urea at the farm level. But the coefficient of the ratio of own price for urea was found to be insignificant. The cause might be the tendency of excessive use of urea at the farm level. This finding is supported by several studies (Islam *et al*., 2005; Hossain *et al*., 2003; Mahmood, 1995; Islam *et al*., 2006b). On the other hand, the ratio of urea price had significant ($p<0.01$) substitute effect on the other fertilizers demand. The ratio of own price effect of other fertilizers also found negatively significant ($p<0.05$) on the other fertilizers and the ratio of labor input was found competing for other fertilizers (TSP and MP) use at the farm level. The above findings have important policy implication and reveals that the TSP and MP use at the farm level could be increased by reducing the prices of TSP and MP and increasing the price of urea simultaneously. The coefficient for market orientation was found negative and significant ($p<0.05$) for urea. This findings have two dimension: i) the more market oriented farmers had better cash income and they were using comparatively less amount of urea compared to other fertilizers or use more other fertilizers (TSP and MP) compared to urea and ii) the farmers of the more market oriented farms could gather better knowledge about crop management as they have better interaction with other farmers and related persons through market interaction and thus, using less amount of urea or use more other fertilizers at their farm, vis-à-vis. This finding is also supported by the coefficient of share of other fertilizers

Table 4: Estimated results of determinants functions for urea and other fertilizers (TSP and MP)

	Marginal Effects			
	Urea (OLS)		Other (Tobit)	
Explanatory variables	Coefficient	t-value	Coefficient	t-value
Intecept	0.109	7.60*	0.065	4.03*
Input prices				
Urea price/output price	171.74	1.49	412.54	3.16*
Other fertilizers price/output price	-14.46	-1.42	-24.05	-2.07**
Labor price/output price	-4.25	-0.71	-20.41	-1.99**
Pesticide price/Output price	-3.41	-2.20*	-0.87	-0.49
Other socio-Economic variables				
Market orientation	-0.83	-1.86***	-0.12	-0.23
Dummy for own operated farm	29.20	1.96**	8.32	0.49
Dummy for other source of income	-11.50	-0.72	2.92	0.17
Dummy for communication with extension personnel	18.78	1.32	29.66	1.83***
Infrastructure index	-17.27	-2.45*	-28.42	-3.54*
Share of other fertilizers	-2.21	-3.55*		
Age of household head	-0.14	-0.30	-0.20	-0.27
Schooling of household head	-0.98	-0.53	0.08	0.39
Regional dummy				
Rangpur	-88.06	-2.29**	-51.25	-1.18
Jamalpur	-28.95	-1.56	-62.18	-2.98*
R^2	0.22			
F-value (df 14, 285)	5.62			
Loglikelihood (d.f.13, 286)			-1879.27	

Source: Estimated from the data of field survey 2006. *p<0.01, **p<0.05; ***p<0.1

(OS) in the determinant function for urea use. It implies that if the share of other fertilizers increases the use of urea significantly decreases in the study area. Side by side, the coefficient for communication with the extension personnel was found positively significant ($p<0.1$) for the use of other fertilizers. It implies that the farmers having communication with extension personnel using more TSP and MP at farm level than those who have no communication at all. Thus, the massive extension program might improve the farmers' attitude for using the TSP and MP at the farm level. The coefficient for the own operated farm was found positively significant ($p<0.05$) for urea and it is quite general that own operated farm will use more amount of input than the farm operated by the tenant or owner-tenant farmers. The coefficients for infrastructure index found to negatively significant for both the cases of urea and other fertilizers use at farm level. These meant that in the less developed area transportation cost, trader's profit and availability might limit the use of urea, TSP and MP at the study area. Lastly, the coefficients for regional dummy found negatively significant for urea and other fertilizers for the area Rangpur and Jamalpur, respectively and these findings also support the findings from the Table 1 and 2.

CONCLUSION AND RECOMMENDATION

It was found from the study that the farmers were using more or less inorganic fertilizers for growing all crops in the study area. Among these fertilizers, the primary plant nutrients (urea, TSP and MP) consist about 99% of total fertilizer use at farm level and secondary plant nutrients (gypsum and zinc) have very insignificant use in the study area. The study also reveals that farmers of the study area were using excessive urea and fewer amounts of TSP and MP and the farmers who were using less amount of urea at their farm, alternatively, they were using more amounts of TSP and MP at their farm and market oriented farm was using better combination of inorganic fertilizers than the less market oriented farms.

The use of TSP and MP at the farm level could be increased by reducing their prices and increasing the urea price at the farm level, simultaneously. Side by side, massive extension program regarding the balance fertilizer use could also increase the use of these two fertilizers at farm level and reduce the tendency of using excess urea. Though, no significant price effect was observed at the existing price level for using urea at farm level. It did not necessarily imply that if the urea price increase at farm level did not affect any on the consumption of urea in future. Moreover, the use of better combination of TSP and MP alone with urea might reduce the tendency of using more urea because of better response of plants to fertilizers use. The effective mean of reducing prices of TSP and MP is providing price subsidy in the country. But, there is a budgetary constraint to provide subsidy by the government of Bangladesh. As the pricing, production, procurement and distribution of urea is under the control of public sector (Islam *et al*., 2006a), government of Bangladesh could increase the urea price and earn extra revenue. And this extra revenue earned from urea sale could be provided as price subsidy for TSP and MP at farm level. In the year 2001-2002, the total urea and other fertilizers (TSP and MP) consumption were about 69, 20, 13 and 7% for TSP and MP, respectively) of total fertilizers consumed in the country (MOA, 2004). Therefore, extra revenue earned from urea sale by increasing the price of urea by one unit could be provided as price subsidy for TSP and MP by on an average 3.45 unit.

The projected cross and own price effect of inorganic fertilizers on their use at farm level is shown for different combinations of inorganic fertilizers prices in the Table 5. These are estimated by solving the model of other fertilizers for only change in inorganic fertilizers prices and assuming other variables are constant. Extra revenue earn from the urea sale by increasing the per kg of urea price by BDT 1.00 and providing subsidy for other fertilizers by BDT 3.45 could increase the other fertilizers use by 60.36 kg ha^{-1} of land at the farm level (combination 1) and if urea price increased by BDT 2.00 per kg and extra revenue earned was given as subsidy by BDT 6.90 per kg for other fertilizers then other

Table 5: Projected per hectare increase in the use of TSP and MP at the farm level

S. No.	Increase in Urea price (Tk kg^{-1})	Subsidy for TSP and MP fertilizers (Tk kg^{-1})	Estimated increase in TSP and MP use (kg ha^{-1})		
			Own price effect	Cross price effect	Total effect
1	BDT 1.00	BDT 3.45	10.11	50.25	60.36
2	BDT 2.00	BDT 3.45	10.11	100.50	110.61
3	BDT 2.00	BDT 4.00	11.72	100.50	112.22
4	BDT 2.00	BDT 5.00	14.64	100.50	115.14
5	BDT 2.00	BDT 6.00	17.57	100.50	118.07
6	BDT 2.00	BDT 6.90	20.21	100.50	120.71

Source: Computed from Table 4 and Appendix 2, Note: BDT = Bangladesh currency Taka. Average weighted output price in the study area is BDT 8.21 and US$ 1= BDT 68.5

fertilizers use at farm level would be increased by 120.72 kg ha^{-1} of land (combination 6). Among the different combinations, combination 3, 4 and 5 could be followed and yet, there will be some revenue excess from urea sale. The increase of the farm level TSP and MP use will reduce the use of urea substantially in the macro level. So, the revenue income from urea sale would be reduced in the future. Thus, the excess revenue remaining could be used for providing subsidy for TSP and MP in future. Therefore, it is recommended that initially the amount of subsidy for TSP and MP should be higher and gradually the subsidy should be reduced according to the sale of urea in the country.

Note

The main focus of the study was on the primary plant nutrient i.e. urea, TSP and MP use at farm level. The secondary plant nutrient (e.g. gypsum and zinc) is beyond our study. The secondary plant nutrient is known as micro dose of nutrient; need of this nutrient is very few for plant growth and also not for all crops. Moreover, once it is applied in the soil its residual effect remains in the soil for a long period of time.

Appendix 1: Chronology of inorganic fertilizers market liberalization in Bangladesh

Action	Time span	Remarks
1. Public agency, Bangladesh Agricultural Development Corporation (BADC) withdrew from retail and wholesale market at thana (sub-district) levels	1978-83	Experimentally done in Chittagong division and traders response was vigorous
2. Licensing requirement was abolished and restriction on movement removed (except for eight –kilometer border zones with India)	1982-83	
3. Deregulation of fertilizers prices took place	1982-84	Beginning of competition at retail level and lowering the retail price
4. Allowing private traders direct purchase from factory gates and port points	1987	Vigorous response from traders
5. Effect on fertilizers consumption occurred	1987-88	Structural change in fertilizers consumption
6. Free import from world market began	1992	Good response by private traders but persistent fear of oligopoly. Urea pricing, production, procurement and distribution still remain under the control of public sector.
7. Urea crisis took place	1994-95	Partial reversal of reform only for urea
8. Privatization of fertilizers distribution	Since 1987	Increase the price and consumption instability for TSP and MP other than urea. TSP and MP consumption also drastically decreased and urea consumption increased sharply. Ultimately turn to oligopolistic structure at import level for TSP and MP. Urea price is relatively cheap because of public sector interference

Source: Zohir (2001) Islam *et al.* (2006a and b)

Appendix 2: Summery statistics of the variables used in the analysis

Variables	Mean	Standard deviation
Urea (kg ha^{-1})	393.05	125.89
Other fertilizers (kg ha^{-1})	264.43	149.31
Urea price/output price	0.80	0.22
Other fertilizers price/output price	2.15	0.70
Labor price/output price	9.11	3.06
Pesticide price/Output price	7.34	5.80
Market orientation (%)	63.08	19.59
Dummy for own operated farm	0.48	0.50
Dummy for other source of income	0.66	0.47
Dummy for communication with extension personnel	0.50	0.5
Infrastructure Index	4.22	1.02
Share of other fertilizers (%)	39.00	0.13
Age of household head	40.96	10.71
Schooling of household head in years	4.75	4.29
Rangpur dummy	0.33	0.47
Jamalpur dummy	0.33	0.47
Urea price (Tk kg^{-1})	5.97	0.25
Other fertilizers price	16.02	2.86
Weighted out put price (Tk kg^{-1})	8.21	2.43

Source: Field survey 2006

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