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Fertilizer Consumption Scenario and Rice Production in Bangladesh

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INTRODUCTION

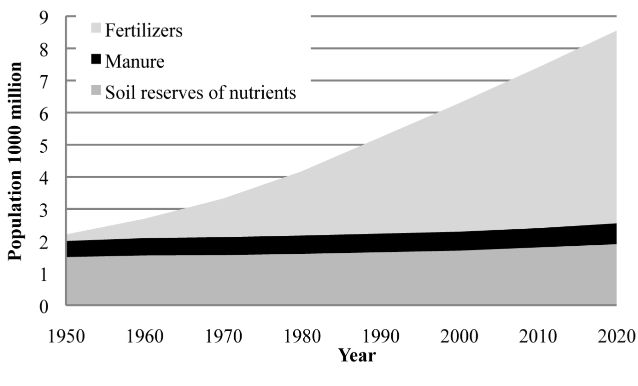
Bangladesh is a densely populated and agriculture-based country. Being staple food, rice occupies about 73% of the total cropped area (Shah et al., 2008). About 75% of the total fertilizer consumption in Bangladesh is for rice production and the rest is for other crops (Zaman, 1987). Due to growing population and urbanization, pressure is going on agricultural land. The scenario of land use shows that the net cropped area is decreasing over last 20 years. In Bangladesh, agricultural scientists and planners are working very hard to provide rice, the most basic need of life. The technological breakthrough in rice production per unit of area, known as the green revolution, provides the means for a considerable increase in production from the existing crop areas. Green revolution is based on the development of high yield potential varieties; however, the key input of green revolution is fertilizers (Tomich et al., 1995), which establishes the yield potential of a variety. It is found that fertilizer contributes as much as 50% of the yield growth in Asia (Hopper, 1993). That is why it appears to be one of the lead inputs to catch high yielding varieties (HYV) yield potential.

To understand the role of fertilizer in increasing crop production, Tandon and Narayan (1990) cited the Nobel prize-winning wheat scientist Dr Norman E Borlaug's dialogue as "If the high yielding wheat and rice varieties were the catalysts that ignited the Green Revolution, then chemical fertilizer was the fuel that poured its forward thrust". This is also true for Bangladesh agriculture because the country has virtually no possibility to increase its cultivable land area. So, food production of this country can be increased through increasing irrigation facilities together with HYV and the appropriate use of fertilizers. The purpose of this review is to provide factual information on the magnitude of fertilizer consumption, with the emphasis on the role of fertilizers to increase food production and enhance food security so as to meet the demand of sustainable crop production in Bangladesh.

CONTRIBUTION OF FERTILIZER TO CEREAL CROP PRODUCTION

Fertilizer provides essential plant nutrients required for the productivity of food grains and other agricultural crop. Therefore, it has linkage with the objective of food security. Bockman *et al.* (1990) visualizes the role of soils reserves of nutrients, manures and fertilizers for crop production (Figure 1).

It appears that fertilizer supports more than half of the world grain production. Regarding fertilizer contribution, Tendon and Tiwarie (2007) opined that the food required for half of the population is met because of fertilizer usage. Globally, China is the highest consumer of chemical fertilizer (32.9 %), followed by the United States (14.9 %). However, among Asian countries, India is the second highest (11.3 %) fertilizer consumer (http://rankingamerica.wordpress.com). Out of the total N consumption in China, about 18 % N is used for paddy production (Heffer, 2009).



(*Source:* Modified from Bockman et al. ,1990)

Figure 1 Global trends in the origin of plant nutrients and its contribution to crop production.

Long-term integrated nutrient management experimental results of Bangladesh Rice Research Institute (BRRI) indicated that fertilizer contributed to total rice yield is 50 % in Boro and 35 % in T. Aman seasons (Figure 2a & b). Results of another long-term experiment conducted at BRRI also showed 47 % contribution of fertilizer for rice yield in Boro and 26 % in T. Aman season (Figure 2c & d).The variation of percentage contribution to rice production may be due to sunlight, temperature and irrigation differences between the two seasons. Among the chemical fertilizers, the contribution of N fertilizer is the highest for rice production. In Bangladesh, it was found that the contributions of N to total rice yield is always higher than that of P or K for both Boro and T. Aman seasons.

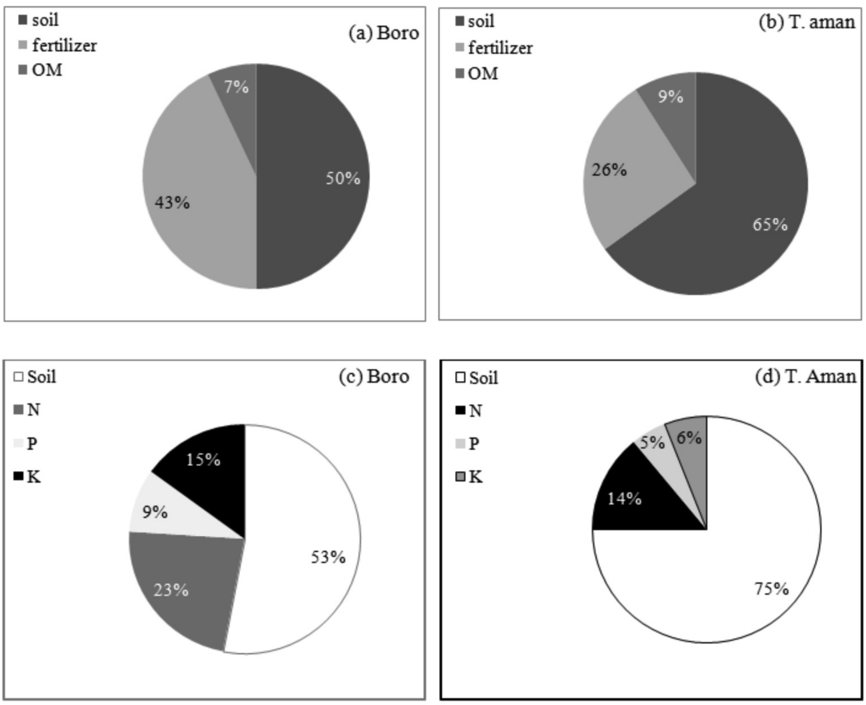


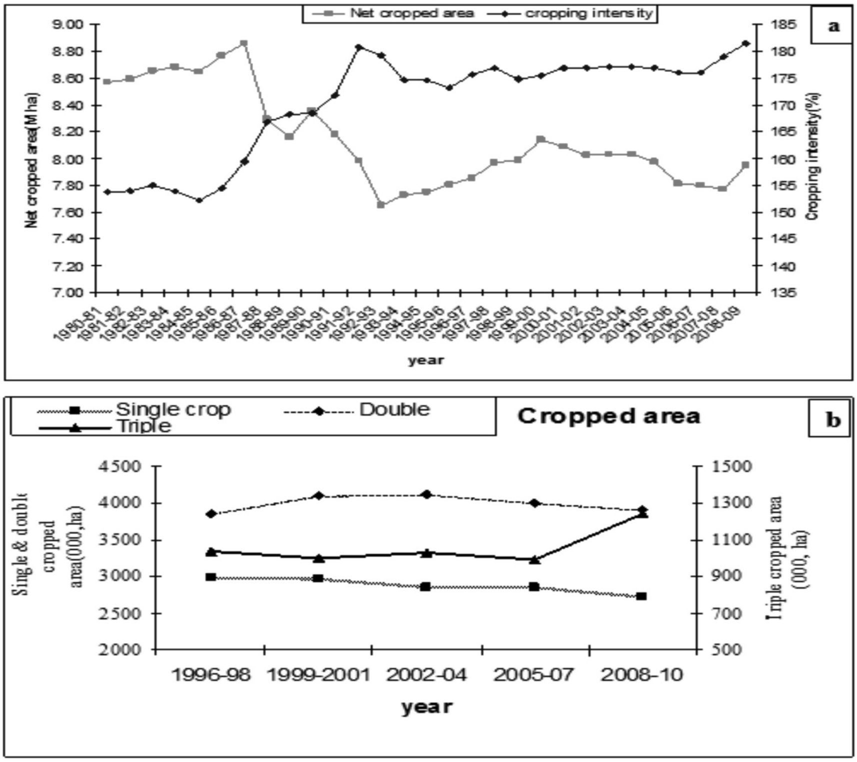
Figure 2 Contribution percentage of (a) soil organic matter, (b) fertilizer, (c & d) soil and N, P, K fertilizers for rice production.

FERTILIZER USE IN BANGLADESH

In 1965, the government of East Pakistan (now Bangladesh) launched a program on growing more food to feed the country's increasing population by providing an opportunity for farmers with the free cost of fertilizers, highly subsidized rate of low lift pump and pesticides. High yielding rice variety IR5 and IR8 were introduced in the country to obtain higher yield per unit area instead of local rice variety. During this period, the use of fertilizer got a momentum in farmer's field. This positive trend is ongoing till now. However, agricultural land area is decreasing over the years due to many factors, for example, urbanization. For this reason, the net cropped area sown is decreasing, although the cropping intensity increases (Figure 3a).

In the year 1980-81, the net cropped area was about 8.60 million ha and the cropping intensity was155 %. However, in 2008-09, the net cropped area was decreased to 7.90 million ha, but the cropping intensity was increased by 183 % (Figure 3a). The increases in cropping intensity was probably shifting from single and double cropped area to triple cropped area during the period of 2005-07 and onward (Figure 3b).

Net cropped area decreased, but total crop production increased due to the utilization of the same land several times in a year. This resulted in increasing demand for nutrients, which was reflected by more nutrient deficiencies exhibited by the crops. However, the fertility of soils is not a fixed property; it changes depending on how intensively the land is used, nutrients are added and removed by the crops. It appears from Table 1that the use of major nutrients (N, P, K) in different cropping pattern showed input-output balance was negative for N and K, but for P it was positive. So, to maintain the existing yield level, it needs higher level of N and K fertilization. It was found in a long-term experiment on rice that application of 23 years (46 crops) of complete fertilizers with optimum dose in the same plot did not maintain experimental inception yield. The yield decrease was 17% indicating soil fertility is decreasing even though complete fertilizer doses were applied (Figure 4a). Similarly, in control the treatment, the yield decrease was 31.42%. Yadav and Alok (2009) reported that crop productivity is declining even after applying recommended dose of N, P, K fertilizer in rice-wheat system. On the other hand, closer experimental inception yield was obtained when addition of extra 18kg N and 45 kg K ha^{-1} in 47^{th} Boro rice crop with previous optimum fertilizer dose. It means that maintaining high yield or to obtain higher production in future needs higher level of N and K fertilization.



(*Source:* BBS 2011, 1999)

Figure 3 Scenario of (a) net cropped area and cropping intensity of last 30 years (1981-2009)
(b) total cropped areas covered by single, double and triple cropping of last 15 years (1996 – 2010) in Bangladesh

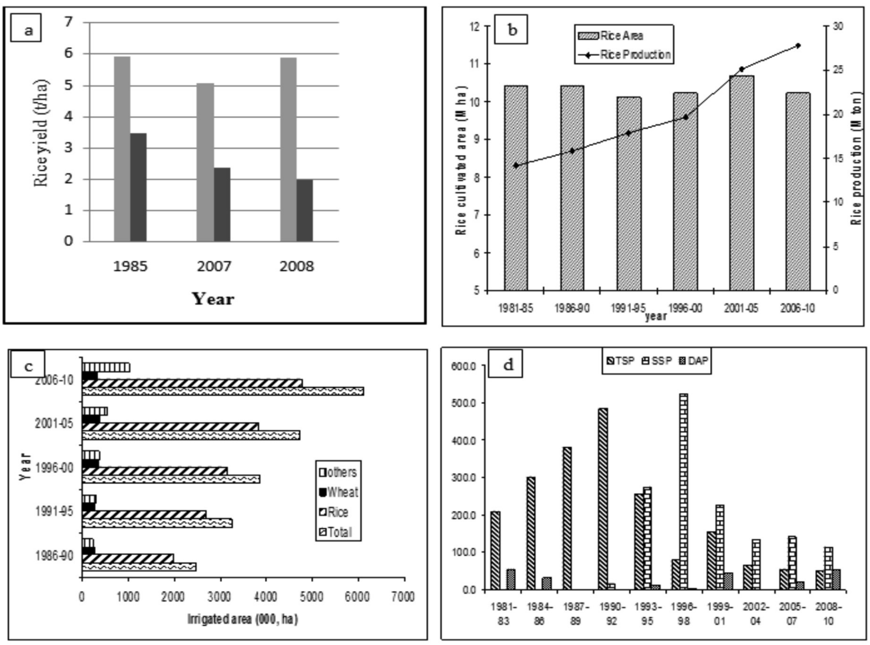
Table 1 Estimation of nutrient depletion in major cropping areas of Bangladesh

Major cropping pattern	Total yield (t/ha/yr)	Input			Output			Balance		
		N	P	K	N	P	K	N	P	K
		(kg/ha)								
Boro-Fallow-T. Aman	8.0	248	49	118	324	32	234	-76	+17	-116
Boro-T.Aus-T.Aman	11.5	350	60	151	469	57	368	-119	+3	-217
Boro-GM-T.Aman	8.0	285	-	135	324	32	240	-39	+28	-105
Mustard-Boro-T.Aman	9.5	378	73	183	404	95	326	-26	-22	-143
Potato-T.Aus-T.Aman	38.0	386	67	220	430	53	435	-44	+14	-215
Potato-jute-T.Aman	36.0	380	70	240	385	55	496	-5	+15	-256
Mustard-Jute-T.Aman	7.5	340	75	205	430	79	429	-90	-4	-224
Wheat-T.Aus-T.Aman	10.0	335	65	166	420	64	292	-85	+1	-126
Wheat- Mungbean-T.Aman	8.0	275	64	190	305	52	284	-30	+12	-94
Sugarcane+Potato intercropping	100.0	190	55	150	210	60	320	-5	-5	-170

(*Source:* MOA, 2007)

RICE CROPPED AREA AND TOTAL RICE PRODUCTION IN BANGLADESH

The food security of Bangladesh is mainly dependent on rice production. The rice producing area of the country is more or less constant from the year 1981 to 2010, but the total production of rice is increasing from the year 1981 to 2010 (Figure 4b). In the year 1981, total rice production was around 14 million tons, but in 2010 rice production was around 28 million tons. The increasing production may be the collective efforts of high yield potential rice variety supported by higher amount of fertilizers as well as higher coverage of rice land with irrigation water (Figure 4c). The resultant effect is double in the yield of rice. According to FAO (2003), the rate of growth was about 62.6 %.



(*Source:* BBS 1999, 2011)

Figure 4 (a). Complete yield response of fertilizer application last 23 years (b) total rice cultivated area and rice production of Bangladesh (c) total irrigated area and coverage by rice, wheat and other crops (d) Use of phosphatic fertilizer in Bangladesh. Where, TSP = triple super phosphate, SSP = single super phosphate, and DAP = di ammonium phosphate

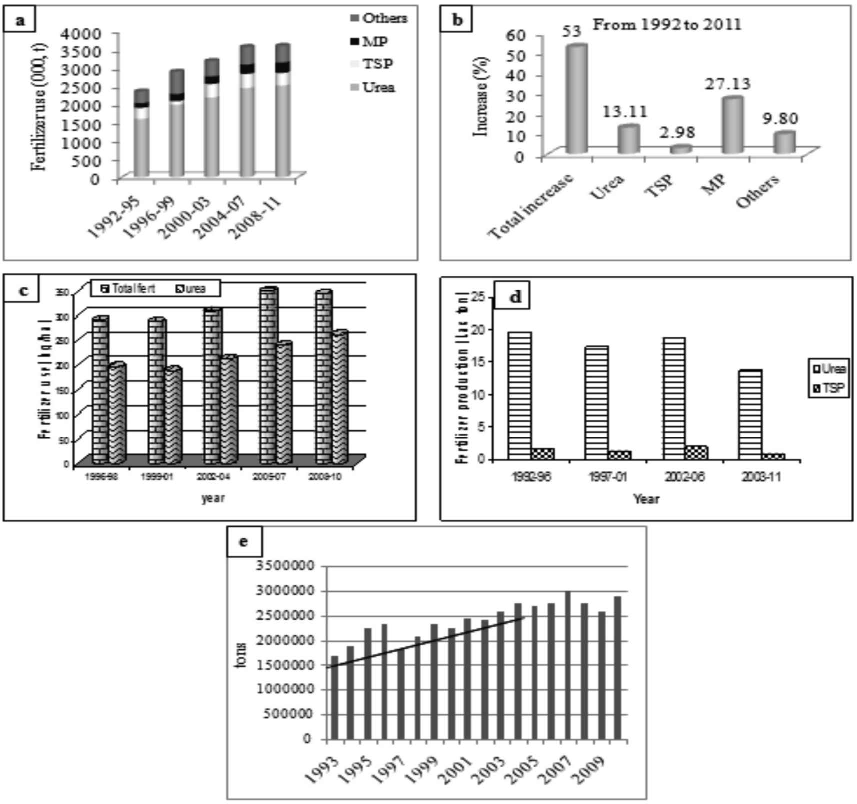
THE FERTILIZER CONSUMPTION OUTLOOK IN BANGLADESH

It was observed from sales in Bangladesh that nine types of fertilizers were sold in the country and ranking of fertilizer use in crop production was based on the amount of each fertilizer sold year wise (Table 2). Assuming sold of fertilizer amount considered here as the use of fertilizer in crop production. In the ranking of fertilizer use urea, triple super phosphate (TSP) and murate of potash (MP) most of the time stands first, second and third position respectively. In 2007-08, TSP and MP both ranked second position but in 2000-01 single super phosphate (SSP) ranked in third position and the onward subsequent years SSP sales or use ranked in fourth or fifth position. Besides these most of the time use of di ammonium phosphate (DAP) was ranked fifth or sixth in position. As a P source farmers are using SSP and DAP in their field (Figure 4d).

The introduction of fertilizer responsive HYV rice in the country in mid-60's, coupled with the government favorable policy for fertilizer distribution and price controlling, resulted in a rise of fertilizer consumption from 2500 thousand tons to 3800 thousand tons during the year 1992-95 to 2008-11 (Figure 5a) and during this period, total fertilizer use increased by 53%. If we compare this increase and look into the proportionate increase among the three major fertilizers (Urea, TSP and MP) and the remaining fertilizers considered as others, MP and urea fertilizer percent increase use was 27.13 and 13.11 (%), respectively (Figure 5b). Increase level of MP and urea fertilizer use by farmers may create a second step momentum to reap good harvest in their small piece of land. In other words, to sustain high productivity of land it needs higher amount of N and K fertilizer use.

The total fertilizer consumption is considered here as national sales of fertilizer for the corresponding years. So, total fertilizer use per unit cultivated area is increasing and at the same time the use of urea fertilizer is also increasing with the increase of total fertilizer use (Figure 5c). It appears from the figure that the per hectare fertilizer consumption was increased from 275 kg to 350 kg during the period of 1996- 2010. Moreover, the amount of urea use per hectare was about 2/3 of the total fertilizer use. Sanchez (1976) reported that N was the fertilizer applied at the largest quantity in the tropics.

Urea consumption increased from 1.5 million tons to 2.5 million tons within 10 years in Bangladesh (Ahmed, 2011) (Figure 5d). It means the country's urea production needs to be increased to meet the increasing demand of urea in the country. In contrast, the production capacity of urea in the country is decreased (Figure 5e). In this context, if the country's urea production is not increased, the import of urea fertilizer should be increased. The whole amount of MP fertilizer used in the country is imported.



(*Source:* BBS 1994, 1999, 2008, 2011 & Modified from Ahmed, 2011)

Figure 5 (a) Consumption of different types of fertilizer during year 1992-2011, (b) Percent increase of total fertilizers use during 1992-2011, (c) Use of urea and total fertilizer during period of 1996-2010, and (d) Urea and TSP production trend in Bangladesh (e) Consumption of urea in Bangladesh during period of 1993-2009.

Table 2 Ranking of different fertilizer uses for crop production in Bangladesh during last 10 years.

Name of fertilizer	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Urea	1	1	1	1	1	1	1	1	1	1	1
TSP	2	2	2	2	2	2	2	2	2	2	2
MP	3	4	3	3	3	3	3	3	2	3	3
DAP	6	6	5	6	6	5	4	6	3	5	6
SSP	4	3	4	4	4	4	5	5	4	7	-
NPKS	-	8	7	7	7	7	6	4	4	5	4
AS	7	7	8	8	8	8	9	9	-	-	-
Zinc	8	9	9	9	9	9	8	8	6	6	7
Gypsum	5	5	6	5	5	6	7	7	5	4	5

(*Source:* BBS, 2011)

The overall consumption of urea and MP fertilizer shows an exponential growth rate (Figure 6) and its growth rate was 5.45 and 6.15 per annum (Table 3) but the growth rate of TSP was negative (-8.01). Five year's interval (since 1980-84 to 2005-09) growth rate of each major fertilizer decreased over times (Table 4) because of increased fertilizer selling price. It does not mean that the total amount of fertilizer used by farmers in crop production decreases. The growth rate decrease here measures the magnitude of fertilizer quantity use in crop production as compared to previous 5 years' fertilizer consumption.

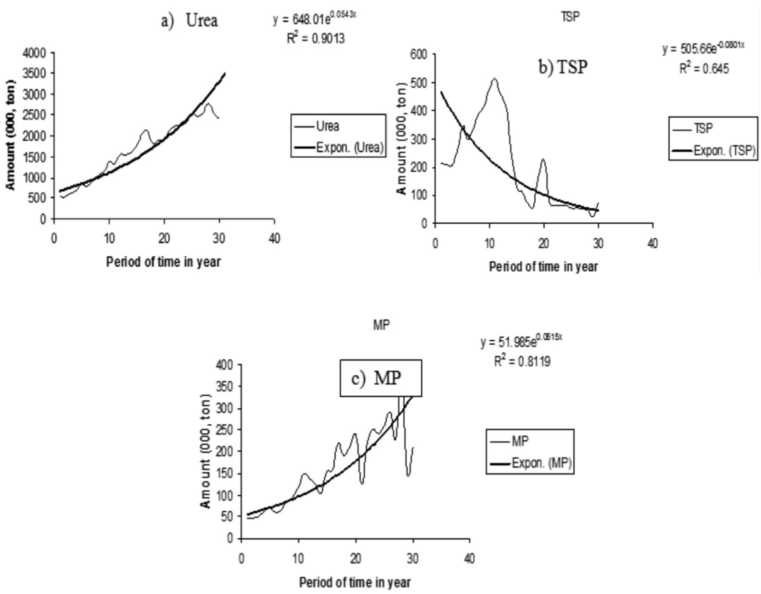


Figure 6 Exponential fertilizer use growth rate of (a) urea, (b) TSP, and (c) muriate of potash (MP) using time series data from 1981 to 2010.

In Bangladesh, mainly three sources of phosphorus based fertilizer are used by the farmer such as TSP, SSP and DAP. Out of the three sources of phosphorus TSP was used as main source of phosphorus in early 1981 (Figure 4d). But the use of TSP was decreased when DAP was introduced as a source of phosphorus and nitrogen. The use TSP also drastically reduced with the introduction of SSP as a source of phosphorus. Therefore, the use of TSP is decreased with the increasing use of DAP and SSP.

Table 3 Growth rate of fertilizer from 1980-81 to 2009-10

Fertilizer	Period of time (1980-2010)
	Fertilizer growth rate (%)
Urea	5.45**
TSP	-8.01**
MP	6.15**

** indicate level of significance at 1%, MP = muriate of potash.

Table 4 Growth rate of major fertilizer consumption (%) of (each 5 years) in Bangladesh

Period of time	Fertilizer growth rate (%)		
	Urea	TSP	MP
1980-84	11.03*	11.71	11.97*
1985-89	13.04**	11.71**	17.27**
1990-94	5.86*	-35.32**	-2.19
1995-99	-2.32	22.66	8.19
2000-04	3.88*	5.40	15.61
2005-09	-0.33	-1.04	-10.78

**, * indicate significance level at 1% and 5%, MP = muriate of potash.

FERTILIZER MARKETING SYSTEM

The pragmatic policies pursued by the Bangladesh Agriculture Development Corporation (BADC) in the field of fertilizer distribution, however, produced an inevitable result and the progress was remarkable from year to years. Considering the importance of fertilizer for stable and expanding agricultural production, various efforts have been made time to time to design an effective fertilizer distribution system in Bangladesh.

Haque (2001) evaluated the fertilizer distribution system based on the availability of right amount in right time with fairly stable price of present completely privatization marketing system (CPMS) over old marketing system (OMS). According to his report, almost 88% of farmers were more or less satisfied with the CPMS when compared to early OMS regarding the time availability of fertilizers. However, the selling price of fertilizer goes little up during the peak season of rice than retailed price due to the short supply (Table 5).

Table 5 Farm level price of chemical fertilizers (Tk/50 kg bag): fluctuation in a year (2005-06)

Month	Urea	TSP	SSP	MP
July*	298.5	637.0	452.0	565.0
Aug.	+1	-20	+33	+9
Sept.	0	+72	+9	+25
Oct.	+6	+10	+26	+31
Nov.	+2	+44	+18	+62
Dec.	0	+52	+15	+78
Jan.	-3	+40	-22	+76
Feb.	+4	+33	-2	+60
Mar.	+11	+51	-3	+107
April	+4	+86	-19	+11.7
May	+4	+79	-7	+129
June	+5	+87	-7	+135

T. Aman rice seasonn **Aus rice** **Boro rice season**

* The fertilizer prices of the month of July considered as fixed price.
MP = muriate of potash, T. Aman= Rainfed rice cultivating season (June to November), Boro = Irrigated rice cultivating season (November to March)

(*Source:* MOA, 2007)

FUTURE FERTILIZER REQUIREMENT FOR RICE/CROP PRODUCTION

Fertilizer, when used in combination with the other inputs such as HYV's and irrigation water results in positive interaction thereby is increasing further its contribution to yield. Future projection on fertilizer requirement have been made on 30 years fertilizer use time series trend analysis that indicated about 3554 thousand ton urea and 361 thousand ton MP will be needed in the year 2020 (Table 6). But based on 30 years phosphate fertilizer used trend in the country showed a slight negative trend indicating farmers are using less amount of P fertilizer in their crop production. The reason of negative trend may be the introduction of SSP and little bit DAP instead of TSP with lower amount from the period of 1993 onward as presented in Figure 9. This trend is not good for sustaining higher yield over time even though phosphate fertilizer had some residual effect on the soil. On the other hand, Basak (2010) estimated population and their food for paddy production up to 2050 (Table 7). According to his projection, estimated the future requirement of urea, TSP and MP fertilizers as 3.917, 2.177 and 1.713 million tons, respectively. In contrast the country production capacity of urea and TSP factory (s) shows a decreasing trend as indicated in (Figure 5e). To meet up the projected urea and TSP production in the country need a policy to renovate existing factories in a modernize manner to have higher level of urea and TSP production or need establishment of higher number of factories to compensate the additional requirement of country produced fertilizer. Otherwise, additional requirement must be fulfill through import of these fertilizer like MP.

Table 6 Projection on fertilizer demand for crop production in Bangladesh

Fertilizer	Thousand metric tons		
	2010	2015	2020
Nitrogen fertilizer	2653.99	3169.69	3553.84
Phosphates fertilizer	297.64	278.20	249.05
MP	278.36	319.84	361.32

MP = muriate of potash

Table 7 Projected population and requirement of paddy with fertilizer of Bangladesh

Year	Population (million)	Paddy	Urea	TSP	MP
		----------million tons----------			
2007	157.75	36.93	2.122	1.183	0.93
2020	191.65	44.87	2.578	1.437	1.129
2030	220	51.56	2.963	1.651	1.297
2040	253.09	59.25	3.402	1.898	1.491
2050	290.83	68.09	3.917	2.177	1.713

MP = muriate of potash. Source : Basak, 2010

INTEGRATED NUTRIENT MANAGEMENT

Integrated nutrient management (INM) is a combination of both organic and inorganic fertilizer. This practice of crop cultivation may reduce fully dependency of chemical fertilizer and simultaneously it improves soil health. Minimum use of chemical fertilizer and to obtain higher yield than to some extend of chemical fertilizer use alone improves soil fertility. It appears from the Figure 7 that Poultry manure (PM) @ 3 t ha^{-1} with 50% of Soil Test Based (STB) fertilizer dose produced similar yield with chemical fertilizer. It indicates INM reduce the dependency on chemical fertilizer without sacrificing total yield. The other source of the fertilizer is organic fertilizers. In these fertilizers mainly beneficial microbes plays a vital role. The addition of beneficial microbes in organic source enhances the soil nutrient status particularly nitrogen fixing bacteria (Naher et al., 2013) and phosphorus by phosphate solubilizing bacteria (Panhwar et al., 2013). These beneficial bacteria have potential to produce plant growth hormones induces extensive root systems which enhance nutrient uptake and photosynthesis in rice (Naher et al., 2009) and can produce organic acids that can chelate heavy metals in the soil (Panhwar et al., 2014).

Fertilizers having the quick capacity to restore the depleted soil nutrients and improve soil fertility so that for higher crop productivity can be obtained and sustain as well. In addition the sustainable, effective and environment-friendly rice production fertilizer application should be based on plant and soil tests (Naher et al., 2011).Integrated nutrient management concept can partially reduce the total dependency on chemical fertilizer for intensively cultivated production system and some fertilizers that may cause to enhance heavy metals in the soil (Acharyya and Shah, 2010).

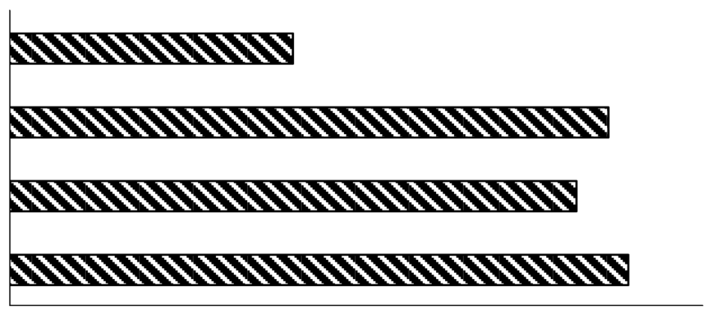


Figure 7 Effect of integrated nutrient management on Boro rice yield. STB= Soil test base fertilizer, PM= Poultry manure

CONCLUSION

With the green revolution, chemical fertilizer becomes an essential input in agriculture. Like other countries, Bangladesh is using huge amount of nitrogen fertilizer. Rice is the major food crop and consumes 2/3 of the total chemical fertilizers. The contribution of chemical fertilizer for rice yield is 26-50 percent. To achieve food security and sustainable crop production for future generation we need to produce more chemical fertilizers or introduction of integrated nutrient management practice.

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