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Fertilizer recommendation for Agriculture: practice, practicalities and adaptation in Bangladesh and Netherlands

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ABSTRACT

For maintaining of soil quality and attainable crop yield, it is required to add proper amount of fertilizers and minimize the misuse of soil resources which is possible by knowing actual situation of soil physical, chemical and biological condition through observation, investigation and soil testing. Soil test is an imperative tool for assessing the fertilizer or manure requirement for sustainable production of crops and for sustaining soil fertility. Soil test and subsequent fertilizer recommendation was pioneered and provided to farmers by the Soil Resource Development Institute (SRDI), Ministry of Agriculture, Bangladesh. SRDI is conducting soil sample analysis in static and mobile laboratories. Through soil analytical results interpretation and or Upazila Nirdeshika[1] data as and where necessary, subsequent balanced fertilizer recommendation for cropping pattern(s) is provided at farmer's level. While BLGG AgroXpertus is an international company located in Wageningen, the Netherlands, which provides soil and plant based fertilization recommendations on the basis of soil analysis, but the recommendation mainly based on information originated from European research. Bangladesh has agricultural potentials and problems related to its soil and land resources such as alteration of soil nutrient status, soil fertility decline, soil acidity, soil salinity, phosphorus fixation in the piedmont areas, decline of soil organic matter etc. But the condition of Europe, as well as the Netherlands, is not always similar with Bangladesh. For instance, a higher sulphur (S) deposition was reported in the Netherlands (05 kg/ha) whereas in Bangladesh, it was negligible. Mineralization rate of organic matter was much higher in Bangladesh compare to the Netherlands. In addition, phosphorus (P) status was almost high in different parts of the Netherlands and it was very low to low in Bangladesh except some piedmont areas. Therefore, it is a prerequisite to adjust and optimize the fertilizer recommendation to the Bangladesh's situation as a better applicability of soil report of this company in Bangladesh as the supplement of existing fertilizer recommendation system. As the mineralization high in Bangladesh, the company can recommend applying the whole amount of organic matter by dividing into 2-3 applications in a year. BLGG AgroXpertus Company can provide support, encouragement and guidance to rural farmers and advice about sustainable management practice of soils. The company can provide leaflets to farmers about the importance of organic matter and benefits of soil test for the establishment of organic matter. This company offers not only fertilizer recommendation of crops but also additional important information, for example, organic matter balance, soil structure, water retention curve and soil type is given to farmers. As BLGG AgroXpertus Company uses traditional as well as NIR method for soil test, they can investigate higher number of soil samples in less time, which would be much efficient and useful for farmers of Bangladesh if supported by SRDI to implement with its existing optimum and balanced fertilizer recommendation.

[1] Upazila Nirdeshika (in Bengali): Land and Soil Resource Utilization Guide (in English) for each Upazila published by Soil Resource Development Institute, Ministry of Agriculture, Bangladesh.

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Key words: *Soil test, fertilizer recommendation, fertilizers, SRDI, BLGG AgroXpertus, organic matter, nutrients and soil quality*

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I. Introduction

Bangladesh is a country in the South Asian territory. It has favorable climate for the production of variety of crops. Per capita cultivable land in the country is about 0.2 acres, which is one of the lowest in the world (SHED, 2012). Solaiman (2014) reported that demand for food, fodder and fuel wood has generated a chain of interrelated economic, social and environmental issues associated with land degradation in Bangladesh. Apart from these, ever increasing pressure of population and their demand for resources has become a challenging issue in Bangladesh. But due to continuous cultivation of crops (and or rice-rice based cropping pattern) to meet up the increasing demand of food, add no, little or less amount of organic matter, high decomposition rate and unbalanced use of fertilizer hampers soil fertility. Intensive land use without appropriate soil management has caused depletion of soil fertility in Bangladesh. The situation has become worse in areas where HYV crops are being grown using low to unbalanced doses of mineral fertilizers, with no or little organic matter recycling (FRG, 2012). Soil is the vital part of an agricultural system and good soil quality is necessary for agricultural productivity. Soil fertility change and or alteration; and land degradation over longer periods was examined and investigated by researchers (Siddique et al. 2014; Kamaruzzaman et al. 2014; Karim & Akter, 2015). Chemical fertilizers and conventional agriculture systems not only cause degradation of soil quality but also increase the production cost. Environmental degradation is another consequence associated with current agricultural practices of Bangladesh. As the country mainly rice based, it covers 75% of cropped area and a small portion of farmers are involved in the vegetable production. Even though the vegetable production is profitable and from vegetable supply of important nutrients through food to farmers' family is evident, still rice based farming is persistent in the country as it is stapled food of the people. However, production of rice is solely based on fertilizer subsidies by the government. Farmers use fertilizer depending on availability during the cropping season, fertilizer price, fertilizer dealer motivation & promotion, assumptions and traditional practices in a locality. General farmers hardly use fertilizer based on the recommendation from authorities such as Soil Resource Development Institute (SRDI) and Dept. of Agriculture Extension (DAE). This might be due to lack of awareness, narrow access of farmers to soil testing facility and inadequate motivation by extension people. Thus, crop production cost becomes higher for input requirement (fertilizers, pesticides etc.) and resource use efficiency remains extremely poor, which is causing degradation of soil, water and land resources. Balanced fertilizer recommendation based on Soil Test Value (STV) from farmer generated soil samples has become imperative in Bangladesh to increase fertilizer use efficiency, maintain soil health, protection of the environment and to reduce production cost. In this regard, different regional static laboratories of SRDI provide Fertilizer Recommendation Card (FRC) to farmers with required fertilizer doses based on soil test considering the cropping pattern of a farmer. This service is not yet practiced widely and or established at 'upazila and union' level (lower administrative units), among the general rural farmers of Bangladesh due to many infrastructural, human resource and govt. policy limitations. FRC service needs higher promotion towards the mass farmer level and at their locality by both DAE and SRDI to ensure justified use of fertilizers during cultivation of crops in every season.

In this case study, there are few questions; (a) what are the existing soil test and subsequent fertilizer recommendation methods in Bangladesh? (b) does the soil test report of BLGG AgroXpertus, Netherlands and SRDI, Bangladesh need further adjustment for usability? (c) how can the benefits of soil tests be explained to farmers for fertilizer recommendation in Bangladesh? In addition, discussion on current practice of fertilizer recommendations, challenges and soil nutrients balance.

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BLGG AgroXpertus is an international company located in Wageningen, the Netherlands, it provides soil and plant based fertilizer recommendation by analyzing soil test results. This company makes reports on the basis of soil analysis and offers not only fertilizer requirement of crops but also additional important information is given to farmers. Rather recently (< 10 years), BLGG AgroXpertus is doing soil tests in different continents such as Asia, Africa, South America and Australia. However, this company offers recommendation mainly based on information originated from European research. Information given on the current soil test report of BLGG AgroXpertus, can be converted or applicable after conversion for South Asia, especially for Bangladesh? For example, is the front page of current soil test report understandable for farmers and advisors? Are recommendations available for crop varieties cultivated in South Asia? Is the calculation of mineralization of organic matter applicable for South Asia? Does the S deposition differ largely compared to European conditions? Does the P status differ largely compared to European conditions? How can farmers and their advisors be supported to use soil tests such as leaflets about fertilizer suggestions, importance of organic matter etc.? On the other hand, STV based fertilizer recommendation of SRDI to what extent can be further implemented as mass farmer community has been elaborated with current practices. Keeping these questions in mind this case study has been prepared to explore, learn and recommend adaptations about soil test and fertilizer recommendations for agriculture in Bangladesh.

For maintaining of soil quality and attainable crop yield, it is required to add proper amount of fertilizers and minimize the misuse of soil resources which is possible by knowing actual situation of soil physical, chemical and biological condition through observation, investigation and soil testing. Soil test is an imperative tool for assessing the fertilizer or manure requirement of the crop and for sustaining soil fertility. Soil test and subsequent fertilizer recommendation was pioneered was provided to farmers by the Soil Resource Development Institute (SRDI), Ministry of Agriculture, Bangladesh. SRDI is conducting soil sample analysis in static laboratories. Through soil analytical results interpretation including upazila Nirdeshika data as and where necessary, balanced fertilizer recommendation for cropping pattern(s) is provided at farmers' level. While BLGG AgroXpertus is an international company located in Wageningen, the Netherlands, which provides soil and plant based fertilization recommendations on the basis of soil analysis, but the recommendation mainly based on information originated from European research. Bangladesh has various agricultural potentials and problems related to its soil and land resources such as alteration of soil nutrient status, soil fertility decline, soil acidity, soil salinity, phosphorus fixation in the piedmont areas, decline of soil organic matter etc. In contrast, the condition of Europe as well as the Netherlands is not similar with Bangladesh. For instance, a higher sulphur (S) deposition was reported in the Netherlands (05 kg/ha) whereas in Bangladesh, it was negligible. Although the mineralization rate of organic matter was much higher in Bangladesh compare to the Netherlands. In addition, phosphorus (P) status was almost high in different parts of the Netherlands and it was very low to low in Bangladesh except some piedmont areas. Therefore, it is a prerequisite to adjust and optimize the fertilizer recommendation to the Bangladesh's situation as a better applicability of soil report of this company as the supplement of existing fertilizer recommendation system. As the mineralization high in Bangladesh, the company can recommend applying the whole amount of organic matter by dividing into 2-3 applications in a year. BLGG AgroXpertus Company can provide support, encouragement and guidance to rural farmers and advice about sustainable management practices of soils. The company can provide leaflets to farmers about the importance of organic matter and benefits of soil test for the establishment of organic matter. This company offers not only fertilizer recommendation of crops but also additional important information, for example, organic matter balance, soil structure, water retention curve and soil type is given to farmers. As BLGG AgroXpertus Company uses traditional as well as NIR method for soil test, they can investigate higher number of soil samples in less time, which would be much efficient, if supported by SRDI to implement at farmer's level with optimum and balanced fertilizer recommendation before and during the cropping seasons.

II. Materials and Methods

This case study is based on several published literatures (journal papers, book, booklets), reports from different governmental and non-governmental organizations. It is literature research combined with own experience and personal contact with advisors of BLGG AgroXpertus, in the Netherlands and Soil

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Resource Development Institute (SRDI), in Bangladesh. The major components of the information were collected from the websites of BLGG AgroXpertus and SRDI. An overview of Bangladesh about its soils, the environment, farmer's condition, soil fertility problem, land use, fertilizer recommendation and services for agriculture has been discussed initially. An overview of BLGG AgroXpertus Company and Near-infrared Spectroscopy (NIR) method of soil test has been discussed. Consequently, discussion about the front page and or soil report including fertilizer recommendation page usability of BLGG AgroXpertus report and SRDI, Bangladesh fertilizer recommendation report have been highlighted. The suitability of BLGG AgroXpertus report in the different group of farmers has been discussed. The available fertilizer recommendations for rice based farming, common vegetables and other crops of Bangladesh have been discussed as for example. These fertilizer recommendations are based on the optimum value of every nutrient through soil test. On the other hand, for mineralization of organic matter, comparison between Netherlands and Bangladesh, organic matter availability, mineralization rate, nutrient balance and the organic matter content of soil has been discussed throughout the case study. The difference of sulphur (S) deposition and phosphorus (P) status between Europe (Netherlands) and Bangladesh has been also discussed. Suggestion to BLGG AgroXpertus Company is also discussed, how this company can serve as an intermediate between farmers and advisors of Bangladesh as well as South Asia. Lacking and strength of this case study with final recommendations for further research is discussed end of this case study.

III. Results

1.1 Background

South Asia is the southern region of the Asian continent which comprises the countries of Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. Agriculture is the principal economic activity in this region and different types of farming systems are available based on the origin and fertility of soil. The major farming systems are rice, coastal artisanal fishing, rice-wheat, highland mixed, rain fed mixed, dry rain fed, pastoral, sparse (arid), sparse (mountain) and it is listed below in map (Figure 01). In this region, usually subsistence based traditional farming system is practiced. But due to economic development and growing demand for food, this subsistence based traditional farming system has gradually shifted to intensified cropping system (Rasul & Thapa, 2003).

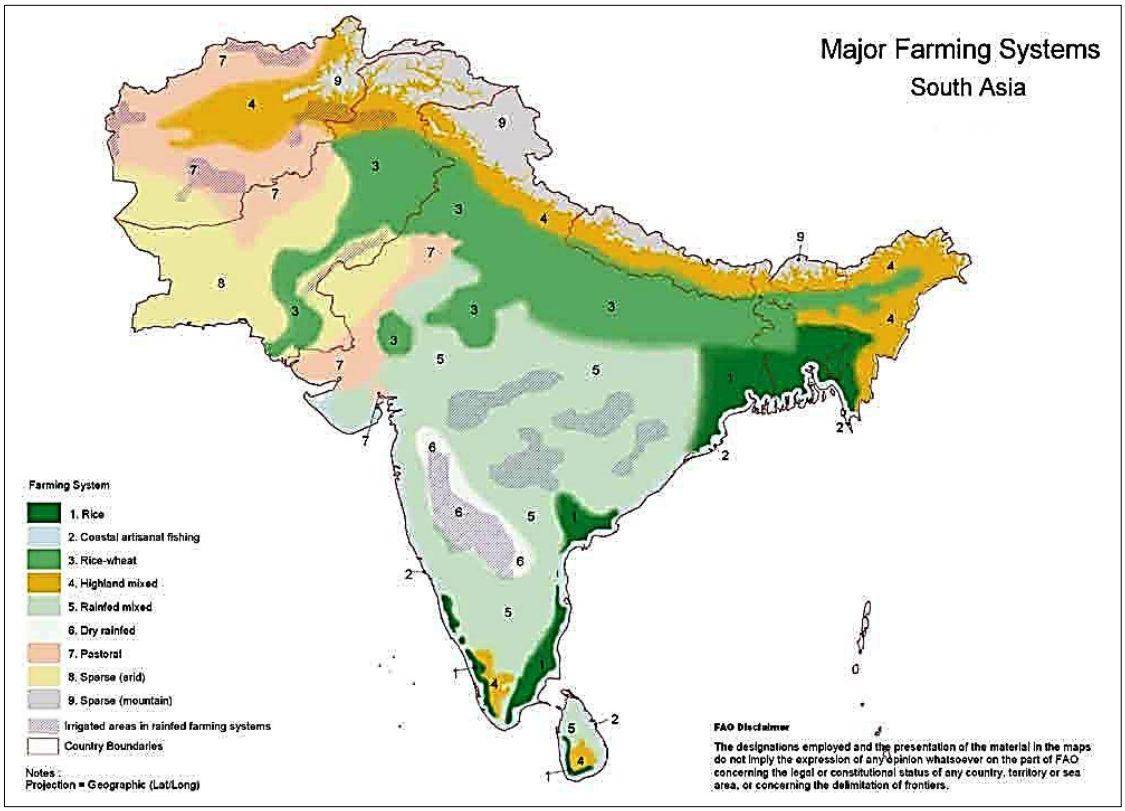

Figure 01. Farming systems in South Asia (FAO, 2001)

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Bangladesh is located in the north-eastern part of South Asia. In South Asia, Bangladesh holds the second position in cereal production, fourth in rice and fish production. On the other hand, Bangladesh shows lowest per capita supply of vegetables, although the country shows highest per capita supply of cereals.

Table 01. Comparison between different South Asian countries about rice production and cereals and vegetables production (Chand, 2012)

Country	Rice production (million tons)	Per capita cereals (kg/year)	Per capita vegetables (kg/year)
India	94.29	152.6	64.8
Bangladesh	30.36	180.9	19.7
Pakistan	6.42	129.8	30
Srilanka	2.35	143.5	40.1
Nepal	2.76	171.3	77.9

As rice is the principle food crop in Bangladesh, it covers 75% of crop area. Small area are covered by vegetable production due to major cropping pattern are based on rice. Farmers of Bangladesh are categorized into major groups.

There are approximately 18 million farm households in Bangladesh. Most are landless or marginal farm operators; there are very few medium or large farm households, though these farmers have traditionally received greater extension support, particularly from the public sector. A large proportion of farm households live below the poverty line (45% overall), though 64% of landless households are in poverty compared to only 16% in the large farm category (Table 02).

Table 02. Farm size structure of Bangladesh

Farm size (Acres)	Number (million) and percentage of households*	Proportion of operated area* (%)	Incidence of rural poverty (%)**
Landless(0.00 to 0.49)	9.39(52.65)	4.50	64
Marginal (0.50 to 1.49)	4.19 (23.53)	18.50	44
Small (1.50 to 2.49)	1.87 (10.50)	18.20	34
Medium (2.50 to 7.49)	2.08 (11.65)	42.40	25
Large (Over 7.50)	0.30 (1.67)	16.40	16
Total	17.83 (100)	100.00	45

Source: * Bangladesh Bureau of Statistics (1996) and ** Bangladesh Institute of Development Studies (2001)

Bangladesh has the favourable climate for the production of a variety of crops although the main characteristics of the climate are high temperature, heavy rainfall and high humidity. The soil of Bangladesh varies widely due to physiography and partly due to climatic variation. Due to variation in formation of soil, the land use pattern is also varied and it is controlled mainly the land type, soil type, local climatic condition and farmer's economic conditions. The whole country divided into 30 Agro Ecological Zones (AEZ) and many subzones based on soil type and variation in microclimate. Every zone has different cropping pattern due to this variation (Huq & Shoaib, 2013). The country has more than 150 million people with 60% of total population and 48% of the total labour force depend on agriculture (Huq & Shoaib, 2013). Major portion of population live below poverty line whereas most of the small scale farmers have maximum 1.0 ha of farmland (Rahman et al. 2007) and some farmers have no land. The farmers without land usually lend from others to cultivate crops and give half of obtained yield to owner of land. The management of each and every piece of land varies widely, as individual farmer divided his land into small pieces (Miah & Uddin, 2005).

1.2 Contribution of fertilizers

Inorganic fertilizer had been introduced in Bangladesh during early 1950's. Mainly used inorganic fertilizers are Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP). Introduction of HYV

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and increase in cropping intensity, the use of inorganic fertilizer increase by many folds after 1990's. However, nitrogen alone constitutes about 75% of nutrient use (Annonomous, 2012; FRG, 2012) and the actual dose of nitrogen fertilizer is less than the recommended dose. The gap between actual dose and recommended dose is more significant for TSP and MoP (Table 03). The gap leads to nutrient imbalance in soil-plant system.

Table 03. Recommended dose and actual dose of major fertilizer for rice (Basak, 2010)

Crop (HYV rice)	Recommended dose (kg/ha)			Actual dose (kg/ha)		
	Urea	TSP	MP	Urea	TSP	MoP
T. Aus[2]	141	101	69	135	28	17
T. Aman[3]	166	101	69	135	30	24
Boro[4]	269	131	121	192	47	37

For urea, major portion is coming from domestic production and for non-urea fertilizers (TSP about 90%, for MoP about 100%); major portion is coming from import (Jahiruddin et al. 2009). The price of urea fertilizer is low due to domestic production and subsidy from the government. It is easily accessible for farmers during cropping seasons. Farmers use different type of fertilizer for the production of wide variety of crops. In Table 04, commonly used fertilizer in the past and present are listed with chemical formula and main supplying nutrients of these fertilizers.

Table 04. Commonly used fertilizers in Bangladesh (Miah & Uddin, 2005).

Name of fertilizer	Formula	Supply nutrients
Urea	$CO(NH_2)_2$	N
Ammonium sulphate	$(NH_4)2SO_4$	N & S
Triple super phosphate	$Ca(H_2PO_4)_2$	P, S & Ca
Single super phosphate	$Ca(H_2PO_4)_2$+ $CaSO_4.2H_2O$	P, S & Ca
Diammonium phosphate	$(NH_4)2HPO_4$	N& P
Muriate of potash	KCl	K
Potassium sulphate	K_2SO_4	K & S
Magnesium sulphate	$MgSO_4.7H_2O$	Mg & S
Zinc sulphate monohydrate	$ZnSO_4.H_2O$	Zn & S
Zinc sulphate heptahydrate	$ZnSO_4.7H_2O$	Zn & S
Zincoxide	ZnO	Zn
Manganese sulphate	$MnSO_4.2H_2O$	Mn & S
Gypsum	$CaSO_4.2H_2O$	Ca & S
Ammonium molybdate	$(NH_4)6Mo7027.H_2O$	N & Mo
Solubor	$Na_2B8013.4H_2O$	B
Boric acid	H_3BO_3	B

The application methods of these fertilizers are not same, as the efficiency of different fertilizer depends on the methods of application. The applications methods also differ between different crops. To increase the efficiency of fertilizer, three different types of application method are usually used in Bangladesh (Table 05).

Table 05. Methods of fertilizer application

Spray type	Application
Broadcast method	To field crops
Localized methods	To horticultural crops
Foliar spray	To trace elements (micronutrients)

[2] T. Aus: Transplated aus rice (paddy) grown during February to May before starts of the monsoon in Bangladesh
[3] T. Aman: Transplanted aman rainfed rice grown during the monsoon season in the months of June to October
[4] Boro: Boro is irrigated rice grown during the winter season, in the drier months of November to March

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1.3 Soil test report of BLGG AgroXpertus, Netherlands and SRDI, Bangladesh

BLGG AgroXpertus

BlGG AgroXpertus is an international company which provides soil and plant based fertilization recommendations on the basis of soil test and analysis. This company also takes an important role in different branches (such as fertilizing, nutritive, soil health, crop health and food) of agricultural system. It provides innovative sources of information for farmer and gardeners of worldwide by sampling, analysis and recommendation related to agricultural work through their partners globally. This organization offers practical operational advice for efficiency improvement and production security by analysis and sampling. This company use both traditional and NIR method for soil test (AgroXpertus, 2014).

Near Infrared (NIR) method

Near Infrared (NIR) is a laboratory method of soil test. It is a simple and convenient method, because of less number of skilled manpower is required in this method. Evaluation of several soil properties at the same time is possible by this method. It is basically application of spectroscopic techniques, combined with data removal and addition technology. This techniques based on NIR spectrum combined with classical methods for all different parameters. It is an accurate analytical technique which estimates standard soil characteristics immediately and does not require the use of any chemicals. In addition, this method does not require large amount of sample materials or highly developed operational skill compared to classical laboratory tests.

Soil test report

The report of soil test prepared by BLGG AgroXpertus contains important soil characteristics; not only fertilizer requirements are given for crops but also additional information is given to the farmer. The report provides detail important information about macro and micronutrients status, physical and biological properties of soil. It is mainly prepared for Dutch condition based on the European research. As the front page of the soil test report delivers detailed information about macro and micro nutrients status, physical and biological properties of soil. This soil test information might be adapted as necessary for existing fertilizer recommendation in Bangladesh.

Three main different groups of farmers are existed in Bangladesh. The first group of farmers are poor and landless. As they have no land to cultivate, they hire land from other farmer or land owner. The front page of BLGG AgroXpertus report contains different nutrient status, physical and biological condition of soil which is not easily understandable for the first group of farmers, as they are illiterate and they have only knowledge about fertilizer but not any nutrient name or details. That's why the report is less applicable or understandable in case of first group. The second group of farmer is also poor but not illiterate; they have knowledge about some plant nutrients but not detailed information should be expected from them. For this group of farmers, the report of BLGG AgroXpertus is more applicable than the first group of farmers. On the other hand, the third group of farmers who are educated and rich, the report of BLGG AgroXpertus are easily understandable for them because of their agricultural know-how. As they are educated, they have knowledge and have desire to know more about soil fertility for sustainable management. They are also concern about environmental risk as well as want to increase the yield. The report is more suitable for this type of farmers, because this report have some additional information which is important for higher yield and sustainable production in large scale.

On the contrary, the first and second group of farmers possess deep traditional knowledge of soil management, as their soil management strategies are based on inherited long term practical knowledge by cultivation of crops in soils. However, the management strategies also depend on farmer's socio-economic condition. On the other hand, the third group of farmers do not have much practical knowledge but their economic condition is well and they are capable of interacting with innovations and modern technologies. As large portion of farmer is poor, use cheaper fertilizer and neglect expensive and high quality fertilizers such as MoP, Zinc etc., although fertilizer like Zinc is

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required in small amounts; instead use lots of nitrogenous fertilizer, as nitrogen fertilizer and or urea is cheap and easily available. In addition, it remains subsidized by the govt. throughout the year.

However, information provided in front page of BLGG AgroXpertus report is easily understandable for most of the advisors of Bangladesh as most of them are educated and they have knowledge about plant nutrients and their management. Although, the information is too much for grassroots advisors, who directly communicate with farmers; do not require the detail information always.

SRDI is the key governmental organization Bangladesh provides soil test and fertilizer recommendation based on soil analysis results at farmer level. The front page of BLGG AgroXpertus report contains detailed information about micro and macronutrients and it is too expensive compared to the soil test report of SRDI in Bangladesh (Appendix 01). Farmers in Bangladesh get information about some specific nutrient supplying capacity and specific fertilizer recommended dose based on cropping pattern. They do not provide report of soil test that could be distinctly comparable to BLGG AgroXpertus but provide fertilizer recommendation card based on individual farmer's specific crops or cropping pattern. The actual cost of a soil sample testing in laboratory is about 630 BDT (currency 18-06-2014, 1BDT= 0.0128999 USD). Farmers give only 63 BDT and rest of the money is subsidised by government (Personal communication, June, 2014). All nutrients are tested and evaluated for their available status in farmers' fields by SRDI (Miah & Uddin, 2005). The soil analysis results of SRDI has some basic difference from the content in first page of BLGG AgroXpertus report .The differences between the content of two reports are given below (Table 06).

Table 06. Difference between two soil test reports of fertilizer recommendation

Parameters	BLGG AgroXerptus	SRDI
N	N-total mgN/kg, C/N ration, N-supplying capacity (kg N/ha)	Total N (%)
K, Ca, Mg and Na	Availability, K-stock and total Ca-stock	K, Ca & Mg (meq/100 g)
P, S and Zn	Availability or PAE µg/kg	µg/g
Micronutrients	Availability of micronutrients B, Si, Mo, Fe, Se (µg/kg)	Only Mo, B & Zn. Occasionally Fe. Other micronutrients depends on the situation of soil
Physical condition	SOM (%), C-organic, C-inorganic, Carbonate lime, pH	SOM (%) and pH
	Sand, silt and clay (%)	Sometimes sand, silt and clay (%)
Clay-humus (CEC) & CEC-saturation	±	-
Soil life	±	-

SRDI provides the nutrient status as very low, low, medium optimum, high and very high by interpretation of soil test results and it is partly similar to the report of BLGG AgroXpertus. But SRDI does not provide fertilizer recommendation if the soil test values fall with in high and very high categories, instead provides a maintenance dose. SRDI measures the different nutrients availability in soil sample by different methods of soil testing.

Table 07. Methods used for different nutrients analysis in Bangladesh (Miah & Uddin, 2005)

Name of elements	Methods of extraction
N (%)	Kjeldahl method
Organic C (%)	Wet oxidation method
P (µg/g)	Modified oslen method (Neutral+ Calcareous soil)
P (µg/g)	Bray and Kurtz method (acid soil)
S (µg/g)	Calcium dihydrogen phosphate extraction
K (m eq/100g)	NNH4OAC Method
Ca (m eq/100g)	NNH4OAC Method
Mg (m eq/100g)	NNH4OAC Method

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Zn (µg/g)	DTPA extraction
Cu (µg/g)	DTPA extraction
Fe (µg/g)	DTPA extraction
Mn (µg/g)	DTPA extraction
B (µg/g)	Calcium chloride extraction
Mo (µg/g)	NH4 oxalate extraction

1.4. Methods of soil test and fertilizer recommendation in Bangladesh

Soil test and fertilizer recommendation in static laboratory of SRDI

The most efficient method for fertilizer recommendation is based on soil analytical results; where soil available nutrient status (very low, low, medium, optimum, high and very high) is considered/determined against each soil sample. SRDI provides soil testing service in their different Regional Soil Testing Laboratory throughout the country and Central Laboratory, Dhaka, Bangladesh. Farmers, students, research organizations, university departments, non-government organizations etc. suppose to collect soil samples following a standard soil sampling technique and submit soil samples for testing in static laboratory. Staff in the laboratory process and test a soil sample for its fertility status. FRC with nutrient status and cropping pattern based recommendation is prepared within few weeks after drying and soil analysis. Fees are set by the govt. for soil analytical results report and or fertilizer recommendation card such as fee in case of a farmer is nominal (about 63 taka). This is most effective tool for location specific and yield goal basis fertilizer recommendation. Additionally, soil sample owner can request which soil nutrients are required to be tested in the laboratory. Generally, nitrogen (N), phosphorus (P), potassium (K), sulphur (S), zinc (Zn), boron (B), calcium (Ca), magnesium (Mg), soil pH, soil organic matter (SOM) etc. are tested in the laboratory. The unique feature of a FRC is that fertilizer recommendation is cropping pattern and crop variety based. Another significant feature is that as cropping pattern based fertilizer recommendation is provided in a FRC, residual effects of nutrients (P, K, S, Zn and B) for the previous crop fertilizers are taken into consideration for the next crops as residual fertilizers. Thus, fertilizer use efficiency becomes higher and total fertilizer requirements narrow down (usually 30-50%) which reduce input costs of farmers.

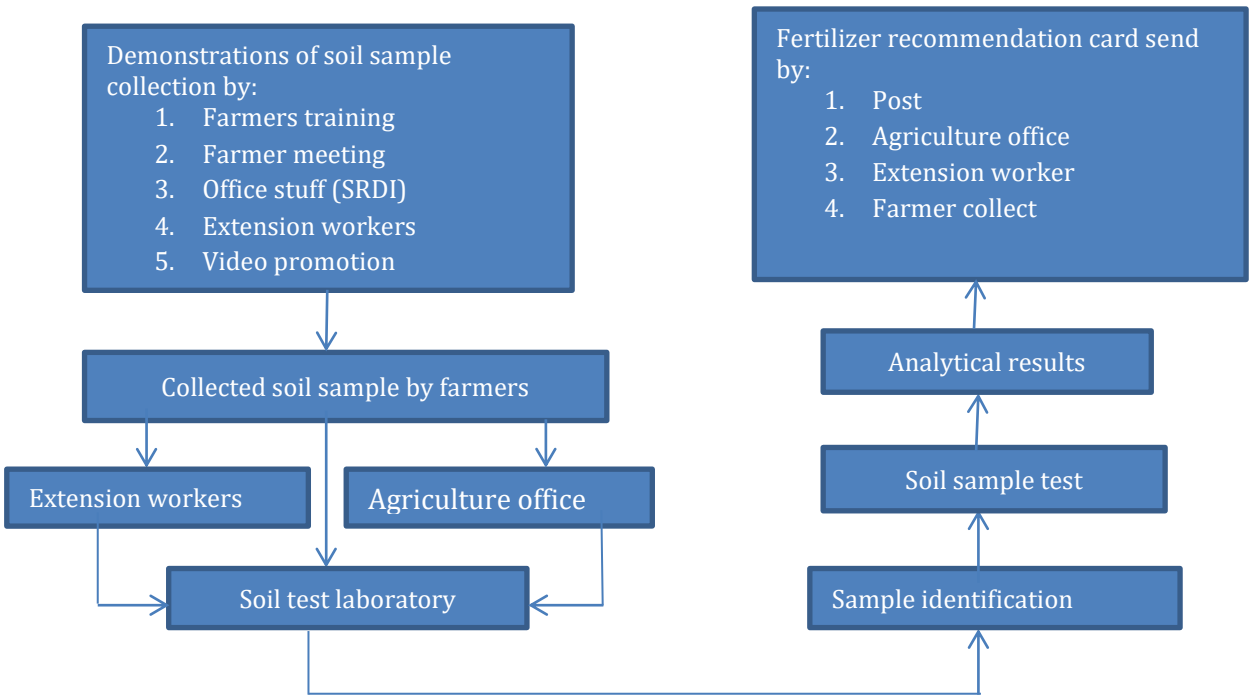

Figure 02. A simplified flow chart of soil test and fertilizer recommendation by SRDI

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Below, there are some examples of fertilizer recommendation for Boro, Transplated Aman rice and potato crop.

For example, fertilizer recommendation for Boro rice (rainfed winter rice during December to May months) for var. BRRI dhan29, BINA dhan-6, BRRI hybrid dhan3 for a yield goal of 7.5 t/ha is shown in Table 08 below.

Table 08. Fertilizer recommendation for Boro rice (rain fed winter rice) (FRG, 2012)

Soil analysis interpretation	Nutrient recommendation (kg/ha)				
	N	P	K	S	Zn
Optimum	0-50	0-8	0-33	0-6	-
Medium	51-100	9-16	34-66	7-12	0.0-1.3
Low	101-150	17-24	67-99	13-18	1.4-2.6
Very low	151-200	25-32	100-132	19-24	2.7-3.9

Source:

For example, fertilizer recommendation for Aman rice (Rainy season rice during July to November months) for var. BR4, BR10, BR11, BR23, BRRI dhan30, BRRI dhan31, BRRI dhan32, BRRI dhan40, BRRI dhan41, BRRI dhan44, BRRI dhan66, BRRI dhan49, BRRI dhan51, BRRI dhan52, BRRI dhan53, BRRI dhan54 and Bina dhan-4, Bina dhan-7, Bina dhan-8, BRRI hybrid dhan4 for a yield goal of 5.0 t/ha is shown in Table 09 below.

Table 09. Fertilizer recommendation for Aman rice (Rainy season rice) (FRG, 2012)

Soil analysis interpretation	Nutrient recommendation (kg/ha)				
	N	P	K	S	Zn
Optimum	0-30	0-5	0-20	0-4	-
Medium	31-60	6-10	21-40	5-8	0.0-0.7
Low	61-90	11-15	41-60	9-12	0.8-1.4
Very low	91-120	16-20	61-80	13-16	1.5-2.1

For example, fertilizer recommendation for potato for var. BARI Alu-6 (Multa), BARI Alu-7 (Diamant), BARI Alu-13 (Granola), BARI Alu-17 (Raja), BARI Alu-25 (Asterix), BARI Alu-28 (Lady Rosetta), BARI Alu-29 (Courage), BARI Alu-30 (Meridian), BARI Alu-31 (Sagitta) and others for a yield goal of 30.0 t/ha is shown in Table 10 below.

Table 10. Fertilizer recommendation for Potato (FRG, 2012)

Soil analysis interpretation	Nutrient recommendation (kg/ha)							Manure (t/ha)	
	N	P	K	S	Mg	Zn	B	CD or PM*	
Optimum	0-45	0-10	0-45	0-5	-	-	-		
Medium	46-90	11-20	46-90	6-10	0-5	0-2.0	0.0-0.5	5	3
Low	91-135	21-30	91-135	11-15	6-10	3.0-4.0	0.6-1.0		
Very low	136-180	31-40	136-180	16-20	11-15	5.0-6.0	1.1-1.5		

*CD: Cowdung; PM: Poultry manure

However, fertilizer recommendation for crops and cropping pattern has been discussed deliberately in the Fertilizer Recommendation Guide, 2012 published by Bangladesh Agriculture Council as shown above for rice against different cereal crops such as wheat, maize, barley, millet; fiber crops such as jute, cotton; pulse crops such as lentil, chickpea, mungbean, blackgram, cowpea; oil seed crops such as mustard, groundnut, soyabean, sunflower; root and tuber crops such as potato; vegetable crops such as cabbage, cauliflower, broccoli, tomato, brinjal etc; spice crops such as onion, garlic, ginger, chilli etc; fruit crops such as banana, papaya, mango citrus, lichi, watermelon etc; plantation crops such as sugarcane, tobacco, tea etc; flowers such as marigold, rose, gladiolus, tuberose, orchid etc; and fodder

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crops such as napier grass, paragrass etc. FRG is considered as the basis of fertilizer recommendation in Bangladesh.

Upazila Nirdashika (and or union guide) based fertilizer recommendation

Soil Resource Development Institute has published soil and land resource utilization guide, typically named as 'Upazila Nirdashika' for all the Upazila (i.e., sub-unit of a district / lower administrative unit). Bangladesh has 488 upazila, which are second lowest tier of regional administration in Bangladesh. SRDI published Upazila Nirdeshika for all these upazila. Upazila Nirdeshika is considered as a comprehensive agricultural planning tool; it consists of several chapters with much useful information such as general overview (location, population, roads, climate, rainfall etc.) of an Upazila, land use, land form, drainage, soil types, soil analytical results, cropping pattern based fertilizer recommendation, potential and constraints of agriculture, and a deliberate soil polygon map of 1:50,000 scale. Location specific balanced dose of fertilizer recommendation for different crops using Upazila Nirdeshika using its soil analytical results can be made in two different ways. Fertilizer recommendation can be made based on mapping unit wise average soil test value and or location specific soil test value. Further clarification and detail steps for making recommendation can be found in each Upazila Nirdeshika of SRDI; and also it can be found in the fertilizer recommendation guide, 2012 published by Bangladesh Agriculture Research Council.

Fertilizer recommendation for cropping patter in AEZs

Basic data of soil, climate and crops is pre-requisite for fertilizer recommendation; this can ensure efficient and economic use of chemical fertilizers and organic manures. Soil related data include pH, texture, organic matter and some other soil properties. Nutrient requirements for a crop also depend on overall environmental conditions and yield potential. For AEZ basis fertilizer recommendation, key attention has been paid to the information of cropping patterns and land type along with soil pH, SOM and nutrient contents (FRG, 2012). Fertilizer recommendation through this method is not of absolute values; rather it is only indicative and subject to variations as arises as the scale is of large area. Extended information about this fertilizer recommendation is available in the Fertilizer Recommendation Guide, 2012.

Online fertilizer recommendation system (OFRS)

SRDI has developed and maintain Online Fertilizer Recommendation Software (OFRS); this software has received several awards for its usability at farmer and local level. Fertilizer recommendation for different crops of different location can be obtained or retrieved from a pre-defined soil analytical data rich digital platform or database. Farmers can obtain fertilizer recommendation by providing some basic information. Key required information is category and name of the crop, land type, soil type and name of the union, upazila and district. A central soil analytical results database based on Upazila Nirdeshika covering the entire country soil samples has been developed as the feedstock of the system which is arranged as district and upazila wise for convenient farmers. The address of the website for having online fertilizer recommendation is **www.frs-bd.com.** Everyone can check the fertilizer recommendation service and obtain FRC after fill-in of some basic information about location, land type, crops and farmer details. SRDI is updating OFRS with updated Upazila Nirdeshika soil data, adding new features and new data sets on regular basis.

Fertilizer recommendation by Mobile Soil Testing Laboratory (MSTL)

To popularize fertilizer recommendation, to spread benefits of balanced fertilizer and to make farmers aware that SRDI has regional static laboratories for soil test, MSTL programme was started from the year 1996. Presently, SRDI possess 10 MSTL van (and or laboratory bus) such as Jamuna, Tista, Korotoya, Titas, Surma etc. These mobile soil testing laboratories moves twice in a year before major cropping seasons such as Rabi cropping season (winter crops) and Kharif cropping season (summer & rainy season) based on a national schedule to different upazila of Bangladesh. Program schedule of MSTL receive attention of national daily newspaper, TV and media during Robi and Kharif cropping season. A mobile soil testing laboratory stays for 3 days in Upazila agriculture Office (UAO), during

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this time period with the help of resource personnel from SRDI and UAO at least 50 fertilizer recommendation cards usually delivered to local farmers to implement balanced doses of fertilizers in their upcoming cropping season.

1.5. Potential of fertilizer recommendation in Bangladesh

Farmer soil sample test in the static regional laboratory or even during MSTL program is rather time worthy, fee dependent and available resource person based governmental facility. To meet the fertilizer recommendation (whether through OFRS or Upazila Nirdeshika Based) requirement for farmers in Bangladesh, soil analytical data-base of Upazila Nirdeshika could be used further with lots of potentiality. Based on the soil data of Upazila Nirdeshika, fertilizer recommendation might be widespread among the general farmers with technical know-how, sufficient promotion and extension activities of Ministry of Agriculture and other non-govt. organizations.

Introduction of NIR spectroscopic technique in Bangladesh

The conventional exhaustive technique for N and CEC determination involves tedious sample preparation and laboratory analysis by chemicals. The conventional soil analysis is expensive and time consuming. The existing knowledge and recent researches (Stenberg et al. 2013) on soil-NIR measurements for soil analysis by the NIR spectroscopic technique could be used potentially for estimation of available nitrogen (N) and cation exchange capacity (CEC) of soils which will optimize fertilization strategy and farmer decision supports. Near Infrared Reflection (NIR) spectroscopy has attracted interest among soil scientists as a possible technique for improved soil analysis for its rapid, non-destructive, cheap measurements as well as possibilities to determine several soil properties simultaneously. During the last two decades, the visible and near-infrared spectroscopy has proved to be a convenient analytical technique that correlates diffusely reflected near-infrared radiation with the physico-chemical properties of materials. A single spectrum allows for simultaneous characterization of various soil and grain constituents. Additionally, NIR spectroscopy has advantages over some of the conventional techniques, such as rapid, timely and less expensive, thus are more efficient when a large number of analysis and samples are required. Moreover, spectroscopic techniques require minimal sample processing and no use of harmful chemicals. This technique is sometime more straightforward than conventional soil analysis and occasionally also more accurate (Shepherd & Walsh, 2002; Chang and Laird, 2002; Brown, et al. 2006; Viscarra Rossel, et al. 2006). NIR spectroscopy shows considerable potential, to predict soil properties such as available N, CEC and the associated calibration models (He, et al. 2005; Stenberg, et al. 2005; Wetterlind, et al. 2008; Nduwamungu, et al. 2009; Kuang and Muazen, 2011), to assess the fate and transport of N in soils and crop, mineralization status and may assist fertilizer decision support (Russel et al. 2002).

1.6 Organic matter balance and its importance for farmers

Soil Organic matter, as one of the main sources to soil productivity, as it influences soil physical, chemical and biological properties of soil. It serves as a store house of plant nutrients, provides food and energy for beneficial organisms. It also improves soil structure, water holding capacity and prevents soil erosion.

The methods used in BLGG AgroXpertus report for maintain soil organic matter is that the supply same amount of soil organic matter in the field which is lost during cultivation of crops. The maintaining method is same in Bangladesh but most of the soil in Bangladesh contains 1% organic matter and some soil contains <1% (FRG, 2012). Most of AEZs contain organic matter at range between low to medium. But Gopalgonj-Khulna Bills, Arial Bills and some piedmont area of Panchagarh district contain high to medium organic matter. On the other hand, St. Martins Coral Islands contains very low-low organic matter. It is also believed that the soil productivity is declining due to depletion of organic matter caused by high cropping intensity. In Addition, crop residue and cow dung widely used for fuel and fodder. Khalil et al. (2005) examined six types of soil in Bangladesh (calcareous, non-calcareous, peat, terrace and acid sulphate). They found that the four types of soil (calcareous, non-calcareous, peat and terrace) lost higher amount of C (60-67%). They also observed that the loss of C varies considerably between different added organic materials. It is 83% for chicken

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manure, 52% for mungbean and 46% for wheat. On the other hand, Rahman et al. 2013; Rahman et al. 2007) observed that the release of N (64-91%) depends on the types, rates of application of organic manures and soil moisture level. In tropics, generally decomposition of organic materials is fast due to high temperature and desirable environmental situations. This consequence is basically highest in upland situation. The highest organic matter depletion occurs in soils of Meghna River Floodplains (33%). The Madhupur Tract (23%), Brahmaputra Floodplains (29%), Old Himalayan Piedmont plain (18%) and Gangetic Floodplains (15%) are the other agro ecological zone where organic matter depletion is high. The maintaining method of organic matter in The Netherlands is not similar to the situation of Bangladesh, as the mineralization rate is too high due to high temperature in Bangladesh. Afterwards, the availability of organic matter is not enough for maintenance in Bangladesh.

How can farmers maintain soil organic matter balance?

Farmers can maintain soil organic matter by incorporating crop residue in soil. They have also cow dung which is also possible to use as organic matter by careful handling. Different houshold wastes (non -edible parts of vegetables and fruits, after-meal wastes) usually throw away or dumped into ditch, ponds and lakes which are also potential source of organic matter. By selecting green manure crops and these crops in cropping patterns, they also improve soil organic matter by incorporated theses crops in soil. They also use water hyacinth and azolla in rice field. Farmers can buy different types of organic matter to enrich the organic matter content of soil. These may be animal manure, compost, vermicomposting, bio slurry and organic fertilizer.

Important options to improve soil organic matter

Soil organic matter is beneficial for soil but building up soil organic matter is a long process. The important options to improve soil organic matter are described below:

Incorporate crop residue: Crop residue like roots, straw, vegetable tops can be recycled or incorporated into soil, because it serves as potential source of organic matter.

Animal manure: Poultry and cattle manure supply organic matter in soil. Cattle manure should be stored in pits and urine should be preserved with the dungs. After 3-4 months they are ready to use in crop field for organic matter.

Compost: Different dried leaves, straw, non-edible parts of fruits, vegetables, non-usable parts of plant, weed, rice husk and different house waste after meal should be placed in inlayers, one above another. To accelerate rotting of materials cow dung or soil should be place between the layers and top of the heap should be covered by b soil. Within 4-6 months, these materials are for ready to use as a compost.

Vermicomposting: Vermicomposting is another type of composting by using earth worms. In this process, kitchen wastes are converting into black nutrient –rich organic matter by using earthworm.

Concentrated organic matter: Different oil cake (master, linseed, sesame and ground nut), slaughter house by products and fish meal are also nutrient rich organic matter. These cakes should be decomposed for 10-12 days before apply to the field.

Establishment of soil organic matter by soil testing

To get optimum yield, it must be known exactly what amount of organic matter present in the soil. Every soil has different organic matter content and a good soil contains at least 3% of organic matter. By Soil testing, it is possible to know the status of organic matter, what amount of organic matter is needed to get desired yield in particular soil. Fertilizer Recommendation Card (FRC) that is given to farmers by SRDI, SOM is taken into consideration and required dose is mentioned in the FRC.

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1.7. Challenges of soil management in Bangladesh

Sulphur deposition

S content in most area of Bangladesh is low to medium. Only St. Martins Coral Islands contains optimum to high S content. Dhaka is the capital of Bangladesh and it is highly polluted by sulphur oxide (SO_2) compare to other part of the country as Dhaka is the most industrial and polluted part. The south-eastern industrial and brick field zone has extremely high SO_2 and the highest concentration is over 100 ppb (0.15kg/ha). The average SO_2 concentration is over 40 ppb (0.06kg/ha) in polluted zone of Dhaka. This area include major road running from northwest to southwest and Buriganga river in Dhaka area. This polluted zone characterized by major emission from brick fields, industries, traffic and navigation routes are located by Buriganga river (Azad & Kitada, 1998).

However, the SO_2 deposition in Dhaka is less than Europe and as well as The Netherlands. Generally SO_2 deposition in most of the part of Netherland is 5 kg/ha (personal contact with supervisor). Then, overall situation of sulphur deposition in Bangladesh is not worrying. Therefore, it is not required to reduce the recommended dose of S fertilizer.

Phosphorus status and P-fixation

Phosphorus is the second most important nutrient (next to nitrogen) that has been found limiting crop production in Bangladesh. Deficiency of phosphorus is widespread in Bangladesh soils. Its deficiency is also quite high in crop growing areas. Most of the AEZ contain very low-low soil P, although Arial Bills contains low-optimum soil P. On the other hand, P status is almost high in different parts of Europe. In Bangladesh, most farmers apply phosphorus fertilizer without judging the actual status of P. Phosphorus mainly obtained from inorganic fertilizer, as they have not enough organic matter or organic fertilizer. In Europe, farmers have enough manure to supply P in field. Then, the P status and maintain is not same for Europe and Bangladesh. Total P content of paddy soil in Bangladesh ranges from 172 to 604 mg/kg (1.72-6.04 kg/ha) in topsoil (Egashira et al. 2003) and average 382 mg/kg (3.82 kg/ha). In addition many soils fix applied P and the average recovery rate is 30% for first crop (Huq & Shoaib, 2013).

Soil acidification and liming

Acid soil (slightly to strongly acidic in reaction) is critical because of its adverse effect on soil fertility and plant productivity. It is estimated that soils of 0.25 mha lands across the country are very strongly acidic (pH <4.5), 3.70 mha lands are strongly acidic (pH 4.5-5-5), and 2.74 mha lands are slightly acidic (pH 5.6-6.5). These soil acidity constraints should be resolved or compromised to attain desirable crop yields. Acid soils possess toxic concentrations of Al^{3+}, Fe^{3+} and Mn^{2+}, lower concentration of P and low availability of bases which together cause reduction in crop yield. Effective management strategies such as liming, application of organic matter etc. for amelioration of acid soil should be implemented for attainable crop yield. Liming is done to raise soil pH and correct soil acidity; it eliminates the toxic effect of Al, Fe and Mn, and increases the availability of P, Mo, ca and Mg (FRG, 2012). During preparation of fertilizer recommendation soil acidity should be taken into consideration.

Soil salinization

There are several saline affected districts in Bangladesh such as Satkhira, Khulna, pirojpur, Barguna, Patuakhali, Noakhali and Cox's Bazar; these areas are relatively flat and suffer inundation by saline water to different degrees. Magnitude and extent of soil salinity are increasing with time in these districts. Saline soils have high content of soluble salts, EC value of saturated extract is more than 4 dS/m at 25°C, ESP value is less than 15 and the pH value is below 8.5. Agricultural production constraints due to salinity, i.e., soil and water salinity, high flooding depth in monsoon season, late draining, heavy soil consistency, poor soil fertility status, high osmic pressure causing reduction in absorption in water and nutrients, poor soil structure and cyclonic storm surges (FRG, 2012). Apart from tailor made fertilizer recommendation salt tolerant crops, improved drainage system, green manuring, mulching could be adopted for crop production in these areas.

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Micronutrients deficiency

Shaheed et al. (2002) reported that many soils in Bangladesh are deficient in micronutrients, especially Zn, B and Mo. Micronutrients deficiency become more evident due to increase of cropping intensity and production of HYV crops. Apart from cropping intensity, low levels of organic matter in soils, little or none retention of crop residues and limited application of animal or organic manures in soils are causing micronutrients deficiency somewhat persistent. Zinc deficiency is mostly widespread in different agro ecological zones on Bangladesh. Boron deficiency is also identified in some parts of the country. However, multiple micronutrients deficiency (Zn, Mn, Cu, B, Mo) from soils of Bangladesh should be addressed with addition of organic manures, addition of crop residues, green manuring and supplementation of micronutrients during macronutrients (NPKS) fertilizer application. Soil testing facility at farmer level and fertilizer recommendation with proper micronutrient doses would be useful to attain desired yield of crops. But during fertilizer and manures application, farmers are not aware of micronutrients deficiency but this cause reduction of yield. Awareness of farmers about micronutrients deficiency is crucial to resolve this prevalent micronutrient problem of soils in Bangladesh.

1.7 Key indications for BlggAgroXpertus to initiate activity in Bangladesh

In Bangladesh, there are opportunities for BLGG AgroXpertus, but there still has to do a lots of research and works on how to proceed? Awareness program, orientation training and communication to farmers are the basis for to do this apart from govt. and non-govt. negotiations and frameworks. Actually the company BLGG AgroXpertus provides soil and plant based fertilizer recommendation based on soil test. This company doing soil test in the entire world but they offer recommendation mostly centred on the information originated from European research. As the situation of Bangladesh is far from the situation of Europe, it is necessary to modify and or adopt plant and soil based fertilizer recommendation based on Bangladesh. As for example, the mineralization rate is high in Bangladesh, it is needed to apply the whole amount of organic matter by dividing 2-3 times in a year. In such case, more researches are required related to Bangladesh condition. In Europe, as well as in the Netherlands, there is no shortage of organic matter and the mineralization of organic matter is low compare to Bangladesh. On the other hand, the organic matter is less and the mineralization rate is so high (average C loses 60-67%) in Bangladesh. The company also calculates organic matter effectiveness for different crops. Therefore, they can identify effective organic matter for crops in Bangladesh, as the mineralization of organic matter depends on types, rate of application and soil moisture level. This is only possible by doing research in Bangladesh situation. For doing research they can use available organic matter effect and different rate of application effect on crops.

In Bangladesh, soil contains very low organic matter. Farmers use large portion of organic matter for fuel purpose. BLGG AgroXpertus can provide leaflet and or conduct motivational programs about organic matter importance, how farmers can maintain or improve soil organic matter. They can also share their knowledge and technology to the advisors and farmers by arranging farmer meeting, community meeting, group discussion with extension workers.

Most of the small holder farmers are poor and they have no and or inadequate access the soil testing. The company can offer facility and motivational approaches to farmers and can take farmer's awareness media activities and advocacy to influence farmers for doing soil test with the help of extension workers. The company can share their knowledge about NIR method of soil test with advisors and existing soil laboratory of Bangladesh. They can directly communicate with extension workers and provide support, encouragement and guidance about sustainable management of soil through optimum fertilizers application based on soil and crop requirements.

As BLGG AgroXpertus company use traditional methods as well as NIR method for soil test, they offer higher number of soil test in less time. For NIR method, only a small amount of soil (a small jar of soil) is needed whereas for traditional method, large amount of soil from different part of field is required. SRDI also analyse soil nutrient in traditional method. In traditional method, skilled manpower is needed and for each nutrient has different extraction method. On the other hand, through NIR method it is possible to measure more than 20 characteristic in every soil sample. In Bangladesh, only SRDI

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provide fertilizer recommendation based on soil test. Out of 64 districts in Bangladesh, only 21 districts have soil test laboratory and they also doing soil test by 6 MSTL programme but this is certainly not enough. Therefore, this company has opportunity to offer soil test and fertilizer recommendation in other 44 (64-20) district of Bangladesh. This could create a great scope for BLGG AgroXpertus and Bangladesh to improve fertilizer recommendation situation.

BLGG AgroXpertus offers not only fertilizer recommendation of crops but added value (for example organic matter balance, soil structure, water management and soil type) compare to SRDI given to farmers. In that way, they can provide information about exact water requirement and fertilizer requirement for cultivation of crops.

IV. Discussion

In reality, it should be considered with the priority that the quality of soil for future generation is a must to meet their food demands. For maintenance of good soil health, it is necessary to incorporate the proper amount of organic matter, balanced fertilizers coupled with the balanced use of agrochemicals to minimize the misuse of input resources. By soil testing, it is possible to know the soil physical, chemical and biological conditions. Excess fertilizer and irrigation are expensive and these are the threat for soil and the environment. On the other hand, less fertilizer and irrigation also risk for getting optimum and or desired yields. By soil testing, it is possible to recognize how much fertilizer, manure and irrigation is required to get the optimum yield of crops. Thereby farmers will be able to reduce their fertilizer and water management cost and also avoid an adverse effect on the environment. As most of the small holder farmers in Bangladesh are poor and they do not have adequate access to soil testing towards balanced fertilizer recommendations for their growing crops. Farmers need extension and policy support, and themselves require more motivation for adoption of sustainable soil management practices through soil test.

Bangladesh is a country with a favourable climate and soil conditions for the production of a variety of crops all the year round. But higher cropping intensity, higher decomposition rate and unbalanced used of fertilizer are contributing in the decline of soil organic matter including natural soil fertility. In addition, the soils of Bangladesh contains the low amount of organic matter and farmers use a small portion of organic matter, as the significant portion of cow dung and crop residue are used as fuel and fodder for livestock. Motivational approaches such as farmer training community meeting, group discussion by agricultural extension workers could motivate farmers to use alternative source for fuel consumption while adequate policy supports from Ministry of Agriculture are required related to increasing use of organic matter instead of use of cow dung and crop residue for fuel purposes. It is also needed to create alternative sources for fuel purposes such as community, group or home based biogas plant could be established for fuel and cooking purposes, even for electricity in rural villages. More researchers are required related to soil organic matter, mineralization rate and decomposing pattern of organic matter in Bangladesh.

Furthermore, a large portion of farmers use lots of urea fertilizer for Nitrogen compare to non-urea (TSP and MP) fertilizer due to the higher price of non-urea fertilizer. In addition, the actual dose of different fertilizer is below the recommended dose and this gap is more significant for non-urea fertilizers. This continuous use of unbalanced fertilizer results in a lower yield of crops and gradual degradation of soil and water. Therefore, policy supports such as low cost soil test and mobile soil testing facility at farmer level required to be increased under soil test extension facility. Land type and cropping pattern based fertilizer recommendation through extension workers are also needed to increase the ability of poor farmers to buy the actual amount of required fertilizer and use balanced fertilizer during all cropping season in a year. It is also obligatory to increase the production of all types of fertilizer both organic and inorganic at the national level. The demand of fertilizer could be meet up by training farmers for production of different types of organic fertilizer such as compost, vermicomposting, household manures, oil cake etc. On the other hand, own country production of inorganic fertilizer requires increasing by supporting the fertilizer industries.

As the agricultural system in Bangladesh mainly rice based, small portion of farmers are involved in vegetable production, although the vegetable production is profitable, because it has short production

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cycle, less risky, and less hire labour oriented crops. It is also possible vegetable production in the home yard and the fallow land where other field crops are not possible to cultivate. External inputs like quality seed, improved infrastructure for storage of fresh vegetables, irrigation facilities and improved technologies are the main obstacles for vegetable production. If these facilities are available, then the successful vegetable production will be possible in Bangladesh condition. More motivations are required for the adoption of vegetable production by the farmers and thereby they would get different nutritional food and money as return from surplus production.

An effort was made to evaluate the soil report of BLGG AgroXpertus in the context of Bangladesh. It was found that some modification is required, as the company BLGG AgroXpertus provides the recommendation based on information originated from European research. Therefore, it is necessary to adjust the recommendation based on soil, land type and crop information of Bangladesh. The company can offer more research-extension based activity and awareness program related to increasing use of organic matter, increase the effectiveness of organic matter for common vegetables and rice crops in Bangladesh. The company can target the rich farmers, as they are educated and able to spend more money for higher yield. In addition, the company can also target other two groups of farmers, but in that case tailor made farmer reach out programs are required with cooperation from people of the extension department. However, this company can offer only supplying capacity of every nutrient, organic matter status in the front page of a report. For S deposition and soil acidification, scanty data is available in the country. The company can provide research in the different district of Bangladesh for S deposition and acidification trends. As the mineralization high in Bangladesh, the company can recommend applying the whole amount of organic matter by dividing 2-3 times in a year. Besides these, they can offer research related to efficient use of P fertilizer and improvement of recycling of P-rich waste, as the P status is very low to low in this country except the piedmont areas. In Bangladesh, P usually is lost with human excreta, crop residue, house waste, slaughter waste, bone and other organic residues. These P source usually not recycled. The company BLGG AgroXpertus has the joint venture for different countries; therefore they can collaborate with SRDI by offering their knowledge and introducing NIR techniques to SRDI. Thereby, SRDI can provide faster and cheaper analysis to the farmers. Other options may be SRDI does all training advocacy and motivational approaches and BLGG AgroXpertus does outsource samples for faster and more extensive analysis. Besides this, the company could also collaborate with the renowned NGOs related to agriculture for orientation of this company in Bangladesh; and offer faster and cheaper soil analysis with the help of these NGOs.

This case study underlines the needs to search more literatures about the actual situation of different nutrient status, social, cultural and environmental situation in Bangladesh. The fertilizer recommendation facility at farmer level based on laboratory soil test analytical data is still inadequate and scanty. While the farmers of Bangladesh have realized the importance and benefits of fertilizer recommendation during crop cultivation because the natural soil fertility of Bangladesh is reducing rapidly hampering crop productivity and yield apart from environmental degradation. Moreover, input costs are also getting higher day by day. In these circumstances, increase of balanced and or recommended fertilizer uses by soil testing for farmers with support of SRDI and Dept. of Extension, Bangladesh, could contribute in resource use efficiency and more economic return from cultivated crops. Information in this case study about Bangladesh would be helpful for this company to serve as an intermediate between farmers and advisors.

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Appendix 01

Soil report or fertilizer recommendation card (FCR) of SRDI in Bangladesh

(This is not a true card; it is a simpler illustration only)

Fertilizer recommendation card based on soil test
Soil Resources Development Institute
Ministry of Agriculture

Farmer,s	Md. Anower Hossain	**Soil test number**	
Father/Husband,s name	Abul Kasem	**Date of sample collection**	
Mother,s name		**Soil depth (cm)**	
Village	Gagonpur	**Land type**	
Mouja number		**Flooding depth (cm)**	
Post		**Soil series**	
Union	Handial	**Name of crops**	
Upazilla	Chutmohor	**Rabi**	Mustard-Boro
District	Pubna	**Kharif-1**	Sesame
Possible cropping pattern		**Kharif-2**	Aman

Analysis nutrient element		**Fertility status**	**Name of fertiliz**	**Season**	**Quantity of fertilizer (g/decimal)**			
					Rabi		**Kharif-1**	**Kharif-2**
Name &unit	**Weight**			**Crop**	Mustard	Boro	Sesame	Aman
N (%)		Low	Urea		1000	1400	660	765
P (µg/g soil)	24	Optimum	TSP		250	250	250	150
K (meq/100g soil)	0.13	Low	MOP		620	605	330	330
S (µg/g soil)	13.9	Low	Gypsum		435	340	340	220
Zn (µg/g soil)		Low	Znc sulphate		30	40	30	15
B (µg/g soil)		Low	Boric acid		20	-	15	-
Ph	7.4	Slightly alkaline	Lime (kg/decimel)		-	-	-	-
Salinity					-	-	-	-
Organic matter (%)			CD/Compost (kg/decimel		10	20	10	10
			Others					

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