Progressive Agriculture 27 (4): 428-434, 2016 **ISSN: 1017 - 8139**

Progressive Agriculture
Journal homepage:http://www.banglajol.info/index.php/PA

Yield maximization of maize through nutrient management

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Abstract

Unbalanced use of chemical fertilizer is a problem in the intensive cropping systems on the Northern part of Bangladesh. Proper nutrient management is essential to maximize maize production and sustain agricultural production while minimizing negative impacts on the soil fertility. The aim of the present study was to investigate nutrient dynamics, maize yields and soil fertility in response to balanced fertilization. A field experiment (2009–2010) was conducted at FSRD site Lahirirhat, OFRD, Rangpur during rabi season 2009-2010 to evaluate Maximizing maize production through nutrient management. Five treatments viz.$T_1= N_{300}P_{50}K_{150}S_{30}$, $T_2=P_{50}K_{150}S_{30}$, $T_3= N_{300}K_{150}S_{30,}$ $T_4= N_{300}P_{50}S_{30}$ and $T_5= N_{300}P_{50}K_{150}$were evaluated for this purpose. The result indicated that the highest grain yield (8.37 t/ha) was found from $T_1= N_{300}P_{50}K_{150}S_{30}$ treatment. The lowest grain yield (7.33 t/ha) was obtained from $T_2=P_{50}K_{150}S_{30}$ treatment. The gross return (Tk.100107/ha) and gross margin (Tk.44951/ha) was higher with T_1 and T_3 treated plot. It may be concluded that proper nutrient management may be the good alternatives for maximizing maize yield and management of soil health at Rangpur region in Bangladesh.

Key words: Yield maximization, nutrient management, maize

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Introduction

Maize is very well-suited to the fertile alluvial soils and can be grown almost any time, except during the rainy season. It is a very common, popular and multi use cereal crop at present situation in Bangladesh. The rise in demand for maize, as human food and from the poultry and fish industries, has led to a trend away from traditional cropping systems and toward rice-maize systems. But actual farm yields of rice and maize fall below their potential. So, to improve the productivity and get maximum benefit from maize farming system further research is needed on nutrient management of maize. Increasing food production to meet growing demands is a major global challenge, particularly in the population-dense and impoverished South Asia, where small holder agriculture predominates (Fischer et al., 2009). Traditionally, rice provides the largest carbohydrate source for most of South Asia's farm families, although with increasing affluence and preferences for fish and poultry protein in diets, maize production has increased from 20.51 to 35.47 Mt in last decade, with grain sold primarily to the feed industry (FAOSTAT, 2015). Maize adoption has been especially high in Bangladesh, where it was cultivated on approximately 1500 ha in 1984, but area rose rapidly to about 0.20 M ha in 2007–2008 and to 0.36 M ha in 2012–2013, largely through the replacement of pulses, oilseeds and wheat (FAOSTAT, 2015).

Bangladesh's alluvial soils and sub-tropical climate are largely suitable for maize, especially during the rabi (winter) season, with both yield potential and the current average yields (16 and 7 t ha [1], respectively), higher than the rest of South Asia (15 and 2.83 t ha 1, respectively) (DAE, 2014; FAOSTAT, 2015; Miah et al., 2013; Timsina et al., 2010, 2011). Maize production in Bangladesh is mainly concentrated in the Northern, Western, and Eastern districts in agro-ecological zones (AEZs) 3, 11, and 19 (Ali et al., 2008; Hussain et al., 2012; Miah et al., 2013). Current production nonetheless lags below national demand, which is ~1.5 M t year [1] (Ali et al., 2008; DAE, 2014). Given the current and projected importance of maize cultivation in Bangladesh, identifying efficient and high-yielding production practices are search and development imperative.

Soil fertility is a dynamic property which varies with crop, cropping intensity input use and erosion. The fertility of the soil has a declined trend throughout the country. This is because of low organic matter content of the soil, intensive cropping system, improper cropping sequence, imbalance use and faulty management of fertilizer. Crop production in Bangladesh will then be sustainable if we apply balance nutrient elements and organic matter against crop removal and nutrient loss phenomena. Farmers of Bangladesh usually use fertilizer on mono crop basis without considering the resident effect of the applied nutrients in preceding crop to the succeeding one. The development of appropriate nutrient management system for different cropping pattern felt an urgent need for soil fertility research.

A crop production system with high yield targets is not sustainable unless balanced nutrient inputs are supplied to soil to counteract the negative effect caused by the removal of nutrients by crops (Dobermann et al., 2002; Dobermann et al., 2003a, 2003b; Khurana et al., 2008; Pasuquin et al., 2014). Intensive cropping with modern varieties, leaching of nutrients by monsoon rains, and acid and light textured soil also favor micronutrient deficiency in Bangladesh soil. Sustainable crop production is also possible through the integrated use of nutrient management (Dobermann et al., 2002, 2003a,b). Integrated nutrient management determines sustainable soil fertility and productivity (Baruah and Baruah, 2015). Continuous crop cultivation without balanced fertilization is one of the major cause of soil degradation (Leite et al., 2011; Chauhan et al., 2012; Hossain et al., 2016).

Maize is an important cereal crop grown in Bangladesh. Maize cultivation is gaining popularity day by day. Hybrid maize becomes importance in Bangladesh due to its higher yield potentially and favorable agro-climatic conditions for its cultivation. Last few years wheat yield is drastically reduced due to environmental condition and is being replaced by maize due to its higher yield potential. But maize is an exhaustive as well as high nutrient- demanding crop. Imbalance chemical fertilizer management and no addition of organic matter is becoming a threat for soil health and sustainable yield. For this reason maximizing maize production through nutrient management is national demand. The overall objective of this study was to promote improved andsustainablemaizeproductionthroughappropriatesoilf ertilizationapproaches.

Materials and Methods

***Site description and experimental design*:** The study was initiated at Farming System Research and Development (FSRD) site Lahirirhat, Rangpur, Bangladesh during 2009-2010 cropping seasons in the farmers field condition of 6 selected farmers to maximize the maize production through nutrient management. The study area is located at 21°24' N latitude and 88°23' E longitude with 31 m above mean sea level. The area mostly falls under high and medium high land areas of the Tista Meander Floodplain with an extent of 946,803 ha (Ferdous et al., 2016). The soils of this region are moderately acidic (pH of 4.6–

6.5), low in organic matter content on the higher land (< 1 %), but moderate in the lower parts (~ 2 %). Overall, the fertility level is low to medium, but the status of K and CEC is medium in most of the places. Soils in general have good water holding capacity (Ferdous et al., 2016). The area receives an annual rainfall of around 2,160 mm with relatively early onset and late cessation.

The land was well prepared by tractor driven disc plough followed by laddering. The initial soil samples of the experimental fields were collected and analyzed following standard methods. The analytical report has been presented in the Table 1. There were five fertilizer treatments (calculated by initial soil analysis) in FSRD site in 2009-2010 (Table 2). Zinc sulphate monohydrate ($ZnSO_4.H_2O$) was used as a source of Zn. Urea, TSP, MOP, Gypsum and Boric acid were used as the sources of N,P,K,S and B, respectively. In FSRD site, the experiment was laid out in a RCB design in three replications which was also replicated in three dispersed farmer's field (Ferdous et al., 2016).

Table1. Initial status of soils of the experimental plots at Lahirirhat FSRD site, OFRD, Rangpur during 2009-2010

Soil characteristics	FSRD site Lahirirhat, Rangpur
Land type and soil texture	Medium High Land and Loamy
pH	6.03
Organic Matter (%)	1.25
K (mleq/100 soil)	2.55 (High)
N(%)	0.06 (Very low)
P(Micro gram/g soil)	30.66 (Very high)
S(Micro gram/g soil)	33.3 (High)
Zn(Micro gam/g soil)	0.52 (Low)
B(Micro gram/g soil)	0.49 (Optimum)

***Crop management*:** The entire amount of organic manure was applied 4 days before final land preparation. Full amount of PKS and 1\3 of N were applied at the time of final land preparation. One weeding was done at 30 days after emergence (DAE). Irrigation was done at 15-20, 30-35, 60-70 and 85-95 days after sowing (DAS). The rest of N was applied into two equal splits at 25-30 DAS and at 40-50 DAS. Other intercultural operation was done as and when necessary. The spacing of maize was 75cm x 25cm. The crop was planted on 3-6 November in 2009 at FSRD site. Preventive measures were taken to control insect and diseases applying appropriate insecticides and fungicides. Harvested date of maize was on 28-30 April, 2010.

***Data collection and statistical analysis*:** After maturing randomly 5 plants were harvested to record the yield and yield contributing characters of maize. Fresh grain yield was harvested from randomly pre-selected central areas (about 9 m^{-2}) of each plot and converted into tons per hectare (t ha^{-1}). Mean data was analyzed statistically and was carried out to analysis of variance (ANOVA) using the MSTAT-C. Further statistical validity of the differences among treatment means was estimated using the least significant difference (LSD) comparison method. Gross return (GR), total variable cost (TVC) and gross margin (GM) have been calculated using the following formula:

GR = Return of main product.
= Yield Price (Tk.)
TVC = All input cost except land cost and interest on operating capital.
GM = GR-TVC

Results and Discussion

***Effect of nutrient management on maximization of maize*:** The yield and yield contributing characters of maize as affected by different nutrient management treatments are presented in Table 2. All the yield and yield contributing characters are differed significantly from other treatments except plant height and 100 grain weight in 2009-2010. The tallest plant was (241.7 cm) found from $T_1= N_{300}P_{50}K_{150}S_{30}$ and the shorter plant was recorded from $T_2=P_{50}K_{150}S_{30}$ treatment. The highest number of grain cob^{-1} (493.7) was obtained from $T_1= N_{300}P_{50}K_{150}S_{30}$ and the lowest number of grain cob^{-1} was recorded from T_2=$P_{50}K_{150}S_{30}$ treatment. The highest 100-grain weight (32.43g) was obtained from T_1= $N_{300}P_{50}K_{150}S_{30}$ and the lowest 100-grain weight (29.47 g) was recorded from T_2=$P_{50}K_{150}S_{30}$ treatment. The highest grain weight cob^{-1} (160.0 g) was obtained from T_1= $N_{300}P_{50}K_{150}S_{30}$.

Table 2. Yield and yield contributing characters of maize at maximizing maize production through nutrient management at FSRD site, Lahirirhat, OFRD, Rangpur, during rabi season, 2009-2010

Treatments	Plant height (cm)	Number of grain cob^{-1}	Grain weight cob^{-1} (g)	100- grain weight (g)	Yield t ha^{-1}
T_1=$N_{300}P_{50}K_{150}S_{30}$	241.7	493.7	160.0a	32.43	8.37a
T_2=$P_{50}K_{150}S_{30}$	232.7	463.0	136.7c	29.47	7.33b
T_3= $N_{300}K_{150}S_{30}$	237.3	489.3	153.7ab	31.30	8.07ab
T_4= $N_{300}P_{50}S_{30}$	232.3	482.0	148.0b	30.23	7.92ab
T_5= $N_{300}P_{50}K_{150}$	237.0	484.0	157.7a	32.40	8.27a
CV (%)	2.13	4.95	2.99	7.30	5.10
LSD value	NS	19.3	8.515	NS	0.769

Note: **Significant for *P*<0.01. NS= Not significant

Table 3. Economics analysis of maize at maximizing maize production through nutrient management at FSRD site, Lahirirhat, OFRD ,Rangpur, during rabi season, 2009-2010

Treatment	Gross return (BDTha^{-1})	Total Variable Cost (BDT ha^{-1})	Gross margin (BDT ha^{-1})
T_1=$N_{300}P_{50}K_{150}S_{30}$	100107	65789	34318
T_2=$P_{50}K_{150}S_{30}$	87663	58777	28886
T_3= $N_{300}K_{150}S_{30}$	96777	62839	33938
T_4= $N_{300}P_{50}S_{30}$	95040	61089	33951
T_5= $N_{300}P_{50}K_{150}$	99240	65539	33701

Exchange rate in 2016: 1 USD = approx. 80 BDT (Bangladeshi Taka); Market price of Maize @ 11 BDT kg^{-1}, urea @ 12, triple super phosphate @ 55, muriate of potash @35, zypsum @10, zinc sulphate @ 140 and boric acid@ 180 BDT kg^{-1}.

The lowest grain weight cob^{-1} (137.3 g) was obtained from T_4 in 2009-2010.Agronomic management practices had significant effects on maize yield over the 2009–2010 study periods. Timsina and Majumdar (2010) indicated that maize grain yields in Bangladesh have been decreasing where maize was grown on the same land for the last 5 to10years.The authors attributed the yield decline to imbalanced and inadequate nutrient application by farmers. Besides, the current nutrient use in the high input maize systems indicates imbalance plant nutrition with very high use of N and less use of P and negligible use of K fertilizers and micronutrients. This has led to nutrient imbalances in soils and lower nutrient use efficiency and economic profitability (Datta et al., 2015; Detchinli and Sogbedji, 2015). This warrants adequate and balanced use of plant nutrients not only for specific farm and ecology but also in production systems using fertilizer best management practices adapted to local situations and farm typologies to achieve better efficiency and nutrient stewardship.

The highest grain yield (8.37 t ha^{-1}) was recorded from T_1= $N_{300}P_{50}K_{150}S_{30}$ and it was identical to T_5= $N_{300}P_{50}K_{150}$ treatment. The lowest grain yield of maize was (7.33 t ha^{-1}) obtained from T_2=$P_{50}K_{150}S_{30}$ treatment (Table 2). Balanced nutrient management application significantly increased maize yield compared to the unbalanced treatment (Table 2). Achieng et al. (2010) found that the used of balanced fertilization increased maize grain yields 108 to 103% higher as compared with control treatments. Abebe et al. (2013) and Detchinli and Sogbedji, 2015 documented similar performance of the mineral fertilizer, and Ferdous et al. (2011a,b) concluded that application of combined nutrient management is the best combination for sustainable maize yield.

Economic analysis: The highest gross return (BDT. 100107ha^{-1}) and gross margin (BDT. 34318 ha^{-1}) was obtained from T_1= $N_{300}P_{50}K_{150}S_{30}$in 2009-2010 while, the total variable cost was (BDT.65789ha^{-1}) found T_1= $N_{300}P_{50}K_{150}S_{30}$in 2009-2010. In addition, FSRD site, the lowest gross return (BDT. 87663ha^{-1}), total variable cost (BDT.58777ha^{-1}) was obtained from T_1= $N_{300}P_{50}K_{150}S_{30}$in 2009-2010and the gross margin (BDT. 28886 ha^{-1}) was obtained T_1= $N_{300}P_{50}K_{150}S_{30}$in 2009-2010 (Table 3). Detchinli and Sogbedji, 2015 found that used of balanced nutrient management increased economic profitability (Datta et al., 2015; Detchinli and Sogbedji, 2015; Ferdous et al., 2011a,b). From this result, it was evident that balanced nutrient management has a great potentiality for maximizing maize production and economic return of the farmer.

Conclusion

The higher yield of maize was obtained from T_1= $N_{300}P_{50}K_{150}S_{30}$ at FSRD site, Lahirirhat in 2009-2010. Balanced nutrient management compensated N, P and K requirement of the crops and showed its higher economic performance hence, it may be concluded that proper nutrient management may be the good alternatives for maximizing maize yield and management of soil health at Rangpur region in Bangladesh.

Acknowledgments

The authors would like to thank the Director General of the Bangladesh Agricultural Research Institute (BARI) for other related supports. The authors also would like to thank the farmers who participated in the farmers' field trials.

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