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Nutrient Requirement for Sustainable Sugarcane Production at Madhupur Tract Soil

K. M. Alam, G. C. Paul, S. M. Bokhtiar, N. Islam and G. M. A. Hossain
Bangladesh Sugarcane Research Institute,
Ishurdi, Pabna, Bangladesh.

ABSTRACT

A field study was conducted to determine the appropriate fertilizer dose on the highest sugarcane yield and maximum economic return at Madhupur Tract soils of Bangladesh. Results revealed that the treatment T_4 having soil test based fertilizers for high yield goal at N_{232} P_{38} K_{240} S_{18} kg ha^{-1} gave the significantly highest sugarcane yield of 141.08 tonnes with gross margin of Taka 197,811 per hectare and marginal benefit cost ratio 5.07 under the study. The second highest cane yield of 134.17 tonnes with gross margin of Taka 192,929 per hectare and marginal benefit cost ratio 9.27 was recorded in T_3 having recommended inorganic fertilizer for moderate yield goal at N_{95} P_{25} K_{100} S_{27} Mg_{12} $Zn_{1.5}$ kg ha^{-1}. The highest yield and gross margin found in T_4 treatment but the marginal benefit cost ratio was lower than that under T_3 treatment due to increase of total variable cost. Thus, the fertilizer level of N_{95} P_{25} K_{100} S_{27} Mg_{12} $Zn_{1.5}$ kg ha^{-1} appeared to be the most profitable combination in this study.

Key words: Suga cane, nutrient, sustainable, production and Madhupur Tract.

INTRODUCTION

Sugarcane is a long duration crop requires twelve to sixteen months for its maturity. During its life span, it requires huge amount of nutrients for its growth and development. Soil is the main source of nutrient supply to the plants but sugarcane soil is loosing its inherent capacity to supply optimum plant nutrient which gradually decline over time due to intensive cropping with high yielding varieties, very little or no use of organic materials and improper soil management for sustainable cane yield. As a result the crop supplied with inadequate amount of nutrients gives lower yield of poor quality sugarcane. Therefore, there is a need to add nutrients to the soil through fertilizers in order to get desired yield.

Fertilizer is a vital component in package of agricultural technology for increasing crop production all over tne world. It was aimed to understand the impact of fertilizer mainly nitrogen, phosphorus, potassium and sulphur as these are called primary nutrients of plants because of its major contribution in crop productivity. Inorganic fertilizers are of paramount importance for enhancing sugarcane production to meet the sugar needs of growing population of the country. Due to high cost of chemical fertilizers and poor economic conditions of the farmers, apply under doses of fertilizers in the fields that produce very low yields of sugarcane. Adequate and balanced fertilization is the key to practice for efficient and profitable production of crops for achieving maximum economic benefits.

Among all the nutrients required by a plant, nitrogen is of prime importance, being an integral part of chlorophyll, protoplasm, proteins and several biochemical processes. The chemical fertilizers have been a significant source of readily available nitrogen and other plant nutrients for maximizing yields and quality of crops (Ahmed *et al.*, 1996). Phosphorus sorption capability is an important soil characteristic of the effects, the rates and plant response to phosphate fertilizer application, the downward movement of applied phosphate and dissolution of rock phosphate in soils. Phosphate sorption by soil is initially rapid, and then slows down with time (Barrow, 1983). Requirements of potassium are higher than any of other macro nutrient for cane yields. Application of potassium fertilizers influenced cane tonnage and sucrose content significantly. Sulphur is the fourth major plant nutrients important as N, P and K for the healthy growth and bumper yield of sugarcane. Higher sulphur content in the cane leaves is also closely associated with high sucrose, high recovery and purity of juice. However, there are some problems in using chemical fertilizer such as adulteration, low supply or unavailability at the time of need and of course, very high investment due to ever increasing cost making the system unsustainable (FAO, 1978). Their costs and other constraints frequently affect the farmers to use fertilizers in recommended quantities.

Long-term trials need be strengthen and encouraged in different agro-ecological zones including all important soils and cropping system in order to monitor the effects of different fertilizers on yields of sugarcane. This will help in the long run the aspects of nutrient depletion and build up aspects besides developing balance sheet of nutrients and studying synergetic effects of nutrients and ultimately help refine the fertilizer recommendations.

Keeping in view, the socio economic status of the farmers and high cost of inorganic fertilizers, this study was undertaken to determine the suitable doses of inorganic fertilizers for profitable sugarcane yields at Madhupur Tract Soils.

MATERIALS AND METHODS

Experimental site and soil characteristics

An experiment was carried out in 2006-07 cropping season at Kaligonj, Gazipur under Madhupur Tract soils of Bangladesh (AEZ 28). The climate of the location was sub-tropical. The soil samples (0-15 cm) were collected from experimental plots, air-dried and passed through 2 mm sieve. The soil (0-15 cm) was loamy in texture having sand, silt and clay of 52.84, 34.00 and 13.16%, respectively with pH 5.90 and %OC 0.99%, total N 0.07%, available P 14.0 ppm, exchangeable K 0.09 meq% and available S 21 ppm (Table 3).

Treatment details and fertilizer application

The experiment consisted of six treatments (Table 1) viz., T_1: Control (No fertilizer), T_2 : N_{120} P_{30} K_{125} S_{25} Mg_{15} $Zn_{2.0}$ (Fertilizer doses as fertilizer recommendation guide 2005 as targeted high yield goal of 100.00$\pm$ 10.0 tha^{-1}), T_3 : N_{95} P_{25} K_{100} S_{27} Mg_{12} $Zn_{1.5}$ (Fertilizer doses as fertilizer recommendation guide 2005 as targeted moderate yield goal of 80.00$\pm$ 8.0 tha^{-1}), T_4 : N_{232} P_{38} K_{240} S_{18} (Fertilizer recommendation as soil test value for high yield goal), T_5 : N_{169} P_{26} K_{212} S_{12} (Fertilizer recommendation as soil test value for moderate yield goal) and T_6 : N_{120} P_{40} K_{100} S_{30} (Farmers practice). The experimental design was a randomized complete block design with three replications. Urea, triple super phosphate (TSP), muriate of potash (MOP), gypsum and zinc sulphate was used as sources of N, P, K, S and Zn, respectively. Full amount of TSP, gypsum, zinc sulphate, one third of urea and MP were applied in trenches as basal and thoroughly mixed with soil by spade prior to setts plantation. The rest amount of urea and MOP were applied in two equal splits; at tillering stage (120 DAP) and at grand growth phase (180 DAP).

Planting technique

Two budded sugarcane setts were planted on December 24, 2006. The dimension of each plot was 6m × 8m in which 6 rows of cane were planted at row to row spacing of 1m; and 0.45m was interplant spacing. Sugarcane variety Isd 34 was used as test crop in the experiment.

Plant sampling and chemiçal analyses

Leaf samples (3th - 5th) from top of main cane stalks were collected from the sampled cane. Midribs were removed from leaf blade and samples were dried at 65^0 C and milled for nutrient analysis. Soil textural class was determined by hydrometer method and soil pH was measured in a 1:2.5 soil water suspension by glass electrode pH meter. Total N was determined by Kjeldahl procedure and organic carbon by Walkley and Black method. Available soil P was extracted with 0.5M $NaHCO_3$ and the amount was determined by Spectrophotometry. Exchangeable K (1N NH_4OAc extractable) was determined by flame photometry and available S by turbidimetric method (Black, 1965) for soil and plant leaf. Necessary intercultural operations like weeding, mulching, earthing-up, tying and mechanical control of insect pests were done when required. Field crops were harvested on December 29, 2007. Juice quality parameters like brix, pol and purity per cent were estimated in randomly selected ten canes from each replication. The data obtained were statistically analyzed by using analysis of variance and least significant difference (LSD) test.

Assessment of juice quality criteria

Juice quality was estimated in randomly selected ten canes from each replication. The following parameters were recorded from the extracted juice:
Brix: It is the soluble solids present in cane juice. Brix was measured using a hydrometer and standardized at 20^0 C.
Pol: It is the percentage of sucrose content in juice. Juice was purified by adding (1g per 100 ml of juice) lead sub acetate in the flask; juice was poured through Whatman 42 filter paper in a funnel. The filtered juice was poured into a pol tube fitted inside an ADP-220 polarimeter and the pol reading was recorded.
Purity: It is the ratio of sucrose content to the soluble solids in juice. The per cent purity was calculated by dividing pol per cent by corrected brix and multiplied by 100.

RESULTS AND DISCUSSION

Yield and yield components, and Brix per cent indices

Yield and its components like germination, tiller, millable cane stalk and Brix of cane are shown in Table 2.

Application of inorganic fertilizer showed significantly better germination, number of tiller, millable cane, yields and brix per cent of cane. Recommended inorganic fertilizer dose of T_2 for targeted high yield goal recorded the highest per cent of germination (57.29%) which was followed by T_4 (55.62%) and then T_3 (53.75%). Considering the tiller and millable cane, treatment T_5 for moderate yield goal of soil test value, produced the highest number of tiller and millable cane (223.54×10^3 ha^{-1} and 156.53×10^3 ha^{-1}, respectively) which was closely followed by T_4 (202.36×10^3 ha^{-1} and 152.57×10^3 ha^{-1}, respectively). Furthermore, it found that T_5 was also statistically similar with the treatments of T_2 (208.68×10^3 ha^{-1}) and T_6 (211.46×10^3 ha^{-1}) in respect of tiller production. Results revealed that the highest yield of cane (141.08 tha^{-1}) was recorded from T_4 of fertilizer dose as per soil test value for high yield goal which was followed by T_3 (134.17 tha^{-1}) of fertilizer dose as per fertilizer recommendation guide'2005 for moderate yield goal. The average yield increased 74 % over control. In response to the recommended, soil test value for high yield goal and farmers' practice, the juice quality parameters of sugarcane as brix significantly influenced over control. The highest brix of 20.30% was found in T_4 treatment, thereof the fertilizer dose as per soil test value for moderate yield goal of T_5 (16.33%), it was found that there was no significant difference with T_1 (16.67%). Majid and Alam (1998) reported that application of different fertilizers significantly influenced the number of millable cane, yields of cane and sugar. Saha *et al.*, (1998) showed that application of different plant nutrients significantly influenced the number of tiller, millable canes, yields of cane and per cent recoverable sucrose. Bokhtiar *et al.*, (1998) reported that the number of tillers, millable cane and yield of cane were increased significantly due to N, P, and K fertilizer application which is in agreement with our findings.

Soil nutrient status after sugarcane harvest

The soils under study were very low in total N and exchangeable K, low in available P and medium in available S. After execution of different treatments of inorganic fertilizers a remarkable decrease inorganic C, P and S; and a slight decrease in N content was observed, while exchangeable K content of the soil increased in all other treatments over control (Table 3) which indicated the need for balanced fertilizer application of sugarcane for obtaining highest yield. The results are supported with the findings of Yadav (1981) who reported that 70 ton crop of sugarcane removes 108-130 kg N from soil.

Economics aspect

Farmers in Bangladesh are faced with many socio-economic problems regarding crop production, so the economic aspect of different fertilizer management packages for sugarcane production needs to be considered. Hence, a cost and return analysis was done considering all the production cost involved in sugarcane cultivation (Table 4). Fertilizers cost were calculated separately as per treatment. From the economic analysis, it was found that the treatment T_4 gave highest gross margin of Tk. 197,811 ha^{-1} with

MBCR 5.07 followed by Tk. 192,929 ha^{-1} with MBCR 9.27 from the T_3 treatment. Thus, the treatment T_3 at fertilizer doses as per fertilizer recommendation guide for moderate yield goal gave the highest benefit among the treatments code.

In conclusion, results of the study revealed that due to highest marginal benefit cost ratio of 9.27, treatment T_3 having recommended inorganic fertilizer for moderate yield goal at N_{95} P_{25} K_{100} S_{27} Mg_{12} $Zn_{1.5}$ kg ha^{-1} as per Fertilizer Recommendation Guide'05 appeared to be the most profitable combination under this study.

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Table 1. Treatments code

Code	Treatment detail
T_1	Control (No fertilizer)
T_2	N_{120} P_{30} K_{125} S_{25} Mg_{15} $Zn_{2.0}$ (HYG) [as per FRG' 2005]
T_3	N_{95} P_{25} K_{100} S_{27} Mg_{12} $Zn_{1.5}$ (MYG) [as per FRG' 2005]
T_4	N_{232} P_{38} K_{240} S_{18} (HYG) [as per soil test basis]
T_5	N_{169} P_{26} K_{212} S_{12} (MYG) [as per soil test basis]
T_6	N_{120} P_{40} K_{100} S_{30} [as per farmers' practice]

HYG-High Yield Goal; MYG-Moderate Yield Goal; FRG'2005- Fertilizer Recommendation Guide, 2005

Table 2. Effects of different fertilizer treatments on the yield and yield attributes of sugarcane

Treatments	% Germination	Tiller ($\times 10^3$ ha^{-1})	Millable cane ($\times 10^3$ ha^{-1})	Yield (tha^{-1})	Brix %
T_1	43.33b	141.67c	103.89d	71.59d	16.67b
T_2	57.29a	208.68ab	137.08bc	114.44c	20.17a
T_3	53.75a	186.73b	131.39c	134.17ab	19.67a
T_4	55.62a	202.36ab	152.57ab	141.08a	20.30a
T_5	45.21b	223.54a	156.53a	122.57bc	16.33b
T_6	45.62b	211.46ab	134.23bc	114.13c	19.77a
LSD (0.05)	3.725	28.17	19.35	16.53	1.57

In a column, the figures having same letter do not differ significantly as per DMRT at 5% level.

Table 3. Status of initial and post harvest soil of the experimental site as affected by different fertilizer management options for sugarcane.

Treatments	Nutrient status in post harvest soils					
	pH	OC (%)	N (%)	P (ppm)	K (meq %)	S (ppm)
Initial soil	5.90	0.99	0.070	14.00	0.09	21.0
Post harvest soil						
T_1	5.83	0.79	0.052	8.00	0.10	8.67
T_2	5.81	0.79	0.063	12.00	0.13	12.67
T_3	5.73	0.79	0.060	10.00	0.12	12.00
T_4	5.76	0.67	0.068	9.00	0.12	10.00
T_5	5.87	0.67	0.063	8.00	0.12	10.00
T_6	5.71	0.71	0.058	8.00	0.10	12.00

In a column, the figures having same letter do not differ significantly as per DMRT at 5% level.

Table 4. Cost and return analysis of different fertilizer management treatments for sugarcane production.

Treatments	Gross Return (Tk. ha^{-1})	Fertilizer cost (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	Marginal Benefit Cost Ratio (MBCR)
T_1	107,385	-	60,286	107,385	-
T_2	166,665	10,346	70,632	156,319	3.73
T_3	201,255	8,326	68,612	192,929	9.27
T_4	212,700	14,889	75,175	197,811	5.07
T_5	183,855	11,886	72,172	171,969	4.43
T_6	171,195	10,152	70,438	161,043	4.29

Price of fertilizer (Tk. per kg) : Urea-6.95 ; TSP-16.0; MP-16.25 ; Zypsum-5.5 ; Zinc sulphate-55; Magnesium oxide-40; Price of cane (Tk. per ton): 1,500.00; Total production cost for growing sugarcane was Tk. 60,286.00 excluding only fertilizer cost.