Nutrient Requirement for Sugarcane and Onion as Intercrop in the High Ganges River Floodplain Soils

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ABSTRACT

The study was conducted during 2011-12 and 2012-13 cropping seasons at Ishurdi under High Ganges River Floodplain Soils to find out the optimum doses of nutrients for sugarcane + onion cropping patterns and also to verify their existing fertilizer recommendations. Eight treatments i.e., T_1 = Soil Test Basis fertilizer dose(STB) for sugarcane and intercrop onion; T_2 =T_1 + 25% N; T_3 =T_1 + 25% NP; T_4 =T_1 + 25% NK; T_5 =T_1 + 25% PK; T_6 =T_1 + 25% NPK; T_7 =75% of T_1 and T8 =Control were considered in this study. The varieties used for sugarcane and onion were Isd 39 and BARI Piaz 1, respectively. Fertilizer application increased the number of tillers, millable canes, cane diameter, stalk height, cane yield, total dry matter yield and juice quality of sugarcane in both the cropping years. The yield of onion as intercrop with sugarcane also increased significantly due to application of fertilizers. The highest yields of sugarcane and intercrop onion were recorded from the treatment T_6 (T_1 + 25% NPK). The study also indicated that application of 25% additional NPK fertilizers (T_6) with the soil test basis fertilizers for sugarcane and intercrops onion recorded the highest gross income, net return and benefit cost ratio compared to other fertilizer treatments and seems to be optimum and economic for both the cropping year.

Key words: Sugarcane, onion, fertilizer, soil test, yield

INTRODUCTION

Sugarcane *(Saccharum officinarum* L.) is an important food - cum - industrial cash crop in Bangladesh. The soil and climate of Bangladesh is congenial for sugarcane production. Sugarcane occupies around 0.22 million hectares of land in Bangladesh with an annual cane production of around 3.64 million tons (BBS, 2018). This is a high input demanding crop and capable of rapidly depleting soil nutrients, such as nitrogen, phosphorus, potassium and sulphur. A crop production system with high yield targets cannot be sustainable unless nutrient inputs to soils are balanced against nutrient removal by crops.

The major constraint for production of crops including sugarcane in Bangladesh is the depletion of soil fertility. Soil fertility is declining with the time mainly due to intensive cultivation with high yielding modern varieties and unbalanced use of chemical fertilizers with little or no use of organic fertilizers. Soil fertility degradation has been reported by many researchers in Bangladesh (Rijpma and Jahiruddin, 2004; Hasan and Alam, 2006; Hossain *et al.*, 2007; Jahiruddin and Satter, 2010; World Bank, 2010; FRG-2012). Thus soil fertility management is of utmost importance for optimizing crop nutrition on both short-term and long-term basis to achieve sustainable

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crop production (FAO, 2006). The yield of sugarcane is low (40.30 t ha^{-1}) compared to world average of 73 t ha^{-1} (BBS, 2018). The low yield at farmer's field can be attributed to imbalanced use of fertilizers and poor management practices.

Sugarcane is a nutrient exhaustive annual crop. It removes about 140 kg N, 25 kg P, 325 kg K and 51 kg S ha^{-1} from the soils with the yield of 100 t ha^{-1} of sugarcane (FRG-2012). The cane height, number of tillers, millable cane stalks, yield of cane and sugar increased progressively with the application of NPK fertilizers (Gurmani *et al.,* 2003, Bokhtiar *et al.,* 2002, Iqbal *et al.,* 2002, Khan *et al.,* 2002, Chaudhery and Chattha 2000). Target yield can be achieved through application of fertilizers on soil test basis (STB) followed by appropriate management practices.

Sugarcane cultivation returns less benefit compared to other short duration fruit and vegetable crops. Because of this, sugarcane is being replaced by different profitable short duration crops. Intercropping with sugarcane might increase the profit of the farmers. Intercropping also shows some beneficial effects on pest and disease control (Abdullah *et al*., 2006). In most cases, intercropping gives higher total production (Gani and Paul, 2005), monetary returns, and greater resource use efficiently and land productivity. Intercropping increases nutritional quality of diet for the farm family (Khan *et al*., 2005), allows better control of weeds and increases land equivalent ratio (Imran *et al*., 2011). Intercropping potato, onion, garlic and cabbage with sugarcane are always profitable compared to sole sugarcane and help to get extra benefit for the farmers (Matin *et al*., 2001; Alam *et al*., 2007; Alam, 2013). The production of intercrop with sugarcane in Bangladesh is localized depending on the soil, environment and market. However, information regarding proper fertilizer management for sugarcane intercropped with onion is scanty.

In Bangladesh, total production of sugar and jaggery are approximately 0.07 and 0.4 million tons, respectively which covers about 25% of total national demand (Patil and Patil, 2011). At the face of such huge demand of sugarcane and gur, there is a need of appropriate fertilizer doses for sugarcane and intercrops that could help sugarcane cultivation profitable and beneficial to improve soil health. Therefore, the present study was under taken with the following objectives i.e. to find out the optimum doses of nutrients for sugarcane + onion cropping patterns and also to verify their existing fertilizer recommendations.

MATERIALS AND METHODS

The experiments were conducted at Ishurdi under High Ganges River Floodplain Soils (AEZ 11) of Bangladesh during 2011-2012 and 2012-2013 cropping seasons in randomize complete block design with three replications. The experiment comprised of eight treatments: T_1 = 100% NPKSZn (STB); T_2 = T_1 + 25% N ; T_3 = T_1 + 25% NP; T_4 = T_1 + 25% NK; T_5 = T_1 + 25% PK; T_6 = T_1 + 25% NPK; T_7 = 75% of T_1 ; T_8 = Control. The physical and chemical properties of soil of the experimental fields are shown in Table 1.

Table 1. Physical and chemical properties of soil of the experimental field at Ishurdi

Properties	Cropping season 2011-12 (Site-1)	Cropping season 2012-13 (Site-2)
Textural Class	Silt loam	Loam
Soil pH	7.63	7.70
OC (%)	0.62	0.67
Total N (%)	0.08	0.080
Available P (μgg^{-1})	8.0	19.0
Exchangeable K (meq%)	0.21	0.20
Available sulphur (μgg^{-1})	22.5	21.0
Available zinc (μgg^{-1})	0.82	0.58

The main crop used in the experiments was sugarcane and the intercrop onion was used. Sugarcane cultivar Isd 39 developed by BSRI was used as the main crop and onion variety BARI Piaz-1 developed by BARI was used as the intercrop. The unit plot size was 8 m x 6 m. Each of the unit plots was separated by 1m and block to block distance was 2 m. Every unit plot had 6 rows with 40 two budded setts placed in each row. The total number of setts per plot was 240. In conventional method, two budded setts were planted end to end system in the month of November. The initial and post harvest status of soil was presented in Table 4 and 5. Full dose of triple supper phosphate (TSP), gypsum, zinc sulphate and 1/3rd of muriate of potash (MoP) and urea were applied in trenches as basal dose and mixed with soil prior to planting of sugarcane setts. The rest amount of urea and muriate of potash were applied as top dressing in two equal splits at 120 and 150 day after planting (DAP). After each application, fertilizers were incorporated into the soil by spade. In the main field,four times of flood irrigation was given at 30,120,150 and 180 day after planting (DAP). Pest and disease management were done following the cultural and chemical practices as per recommendation. Apart from chemical, cultural and mechanical control measures were done for insect-pests and disease management as and when required. No disease infestation was found in the experimental fields. Data on number of tillers at 150 DAP, cane diameter, millable canes, and stalk height, nutrient content of leaf, Brix% and cane yield were recorded for sugarcane.

The intercrop (onion) was planted in between two rows of cane with 20 cm distance between onion rows and 15 cm between two bulbs on 05 November 2011 and 30 November 2012. Half of the total amount of fertilizers needed on the basis of soil test basis was applied for the intercrop compared to sole crop. Full amount of triple supper phosphate (TSP), gypsum, zinc sulphate and half of urea and muriate of potash (MoP) were applied at the time of planting. The rest amount of urea and MoP were applied in two equal splits at 25 and 50 DAP. After applying fertilizers irrigation was given properly.

The bulb yield was recorded for onion. The initial and post-harvest soils were analyzed for soil pH, organic carbon, total nitrogen, available phosphorus, exchangeable potassium and available sulphur. All the recorded data were analyzed statistically using computer based Statistics 10 programs. Economic analysis was also done for the experiment.

RESULTS AND DISCUSSION

Effects on growth parameters, yield of sugarcane and intercrop (onion)

Results presented in Table 2 and 3 showed that in both the cropping year (2011-12 and 2012-13) treatment T_6 recorded the highest number of tillers of sugarcane (238.7 x 10^3 ha^{-1}) and (215.0 x10^3 ha^{-1}) respectively where, additional 25% NPK fertilizer was applied with Soil Test Basis fertilizer dose (STB) 100% NPKSZn in 2011-12 and 2012-13 respectively which was statistically identical to those of the treatments T_2, T_3, T_4 and T_5. The results suggest that application of fertilizers increased the tiller number over that of the treatment T_1 (STB). The cane height, number of tillers, millable cane stalks, yield of cane and sugar increased progressively with the application of NPK fertilizers (Gurmani *et al.,* 2003, Bokhtiar *et al.,* 2002, Iqbal *et al.,* 2002 and Khan *et al.,* 2002,). Application of fertilizers in different combinations significantly increased the number of millable canes both in 2011-12 and 2012-13 (Table 2). In 2011-12, the number of millable canes due to different treatments ranged from 59.0 x10^3 to 104.7x10^3 ha^{-1}. The highest number of millable canes (104.7x10^3 ha^{-1}) was observed in the treatment T_6 which was statistically identical to another treatments .On the other hand the highest number of millable cane (121.0 x10^3 ha^{-1}) was observed in the treatment T_6 in 2012-13. Suggu *et al.* (2010) reported that increasing rates of NPK ha^{-1} increased the number of millable canes per unit area.

Table 2. Effects of fertilizer applied in different combination on growth parameters of sugarcane

Treatments	Cropping year 2011-12 (site-1)				Cropping year 2012-13 (site-2)			
	Number of tillers ($\times 10^3 ha^{-1}$)	Number of millable canes ($\times 10^3$ ha^{-1})	Cane diameter (mm)	Stalk height (m)	Number of tiller ($\times 10^3 ha^{-1}$)	Number of millable canes ($\times 10^3$ ha^{-1})	Cane diameter (mm)	Stalk height (m)
T_1 = STB 100% NPKSZn	218.3b	95.3a	19.37a	3.71a	186.7b	101.0a	18.52ab	3.69a
T_2 = T_1+25% N	229.0ab	99.0a	20.19a	3.82a	200.7ab	107.0a	19.47a	3.70a
T_3 = T_1+25% NP	230.7ab	103.0a	20.05a	3.83a	202.7ab	114.3a	19.50a	3.79a
T_4 = T_1+25% NK	227.0ab	103.0a	20.10a	3.80a	202.0ab	113.0a	19.59a	3.82a
T_5 = T_1+25% PK	230.7ab	102.0a	20.51a	3.90a	203.7ab	115.3a	19.53a	3.80a
T_6 = T_1+25% NPK	238.7a	104.7a	20.64a	3.95a	215.0a	121.0a	19.83a	3.80a
T_7 = 75% of T_1	192.7c	74.7b	17.24b	2.84b	161.7c	80.7b	17.24b	2.70b
T_8 = Control	136.0d	59.0c	13.53c	2.37b	104.0d	62.7b	14.53c	2.03b
CV(%)	5.04	7.55	4.53	10.11	6.08	10.44	4.12	12.73
SE (±)	6.19	4.038	0.496	0.216	6.47	6.140	0.440	0.250

T_1 = N_{171} P_{53} K_{101} S_{15} Zn_3 kg ha^{-1} in 2011-12 and N_{171} P_{27} K_{107} S_{18} Zn_5 kg ha^{-1} in 2012-13 for sugarcane

Figure(s) in a column having same latter do not differ significantly as per DMRT at 5% level

The Table 2 showed the data on diameter of sugarcane which was significantly increased due to application of fertilizers in different combinations both in 2011-12 and 2012-13 and ranged from 13.53 to 20.64 mm in 2011-12 and 14.53 to 19.83 mm in 2012-13. The treatment T_6 showed the highest data on cane diameter both the year but it was identical except T_7 and T_8 treatments. All the treatments produced identical stalk height of sugarcane except T_7 and T_8. The highest stalk height of sugarcane (3.95 m and 3.82 m) was recorded in the treatment T_6 and the lowest values (2.37 m and 2.03 m) were found in the control treatment (T_8) in both the year which was related the finding of Ali *et al.,* 2000 and Xu *et al.,* 2010 who reported that increasing rate of fertilizers increased the plant height of sugarcane.

The cane yield was influenced significantly due to application of different doses of NPK in both the years (Table 3). Fertilizer treated plots produced significantly higher cane yields over the control treatment (T_8) in both the years. The highest cane yield (102.80 t ha^{-1}) in 2011-12 recorded in the treatment T_6 which was statistically superior to all other treatments. Wains *et al.* (2012) also reported that NKP influence sugarcane yield. In 2012-13, the highest cane yield (115.60 t ha^{-1}) was observed in the treatment T_6 which was similar statistically to those of the treatments T_3 (105.80 t ha^{-1}), T_5 (103.00 t ha^{-1}), T_4 (102.63 t ha^{-1}) and T_2 (102.36 t ha^{-1}). Singh *et al.*, 2008 and Xu *et al.*, 2010 also observed that cane yield was influenced significantly by balanced fertilizer.

The treatment T_6 which receiving 100% soil test basis N P K S Zn plus 25% N P K which was statistically identical to the treatment T_3 in 2011-12. Whareas, in 2012-13 it was statistically similar to the treatments T_3, T_5 and T_4. The lowest value was recorded by the control treatment T_8 (Table 3). The highest dry matter yields of 29.9 t ha^{-1} and 24.4 t ha^{-1} in 2011-12 and 2012-13 respectively. Soomro *et al.* (2014) noted that tillers, stem girth, internodes $plant^{-1}$, millable canes, and dry matter were higher with the application of 25% more than recommended fertilizer which coincides in the findings of present study.

The Table 3 presented the results of onion yield as intercrop with sugarcane. Onion yield showing a range of 2.40 to 5.44 t ha^{-1} in 2011-12 and 2.43 to 6.43 t ha^{-1} in 2012 -13 cropping year. In both the cropping year the treatment T_6 produced the highest tuber yield of onion but, in 2011-12 it was statistically similar with the treatments T_1,T_2, T_3 and T_4 and in 2012-13 it was statistically similar to the yields recorded in the treatments T_3, T_4 andT_5 . Bagali *et al.* (2012) observed the similar result on bulb yield of onion to increasing levels of applied NPK. Similar result was reported by Ghaffoor *et al.* (2003) when working with different doses of NPK fertilizers for onion cultivation.

Effects on juice quality

Produced of sugarcane Brix% did not differ significantly with different rates NPK fertilizer application both in 2011-12 and 2012-13 (Table 3). Sugarcane Brix% ranged from 19.03 to 19.74% and 20.42 to 20.69% in 2011-12 and 2012-13 respectively. The Brix% of sugarcane did not vary significantly due to different fertilizer treatments in both the years. This findings band together with Phonde *et al.* (2014) who noted that increasing rate of NPK application had no effect on juice quality parameters such as brix and pol% of sugarcane. The pol% of cane due to different treatments varied insignificantly in both the years. The pol% of cane due to different treatments ranged from 13.04 to 13.46 in 2011-12 and 14.14 to 14.42 in 2012-13. Sarwar *et al.* (2011) also observed that fertilizer application through any forms had no effect on Brix% juice, pol% juice, purity%, CCS% and sugar recovery% of sugarcane which responds the present study.

Table 3. Effects of fertilizer applied in different combination on the cane yield, dry matter yield, onion yield and juice quality of sugarcane at Ishurdi

Treatments	Cropping year 2011-12					Cropping year 2012-13				
	Cane yield (t ha^{-1})	Dry matter yield (t ha^{-1})	Brix (%)	Pol (%)	Onion yield (t ha^{-1})	Cane yield (t ha^{-1})	Dry matter yield (t ha^{-1})	Brix (%)	Pol (%)	Onion yield (t ha^{-1})
T_1 = STB 100% NPKSZn	81.84b	19.8cd	19.14	13.04	4.69ab	94.44b	20.2bc	20.57	14.39	5.27b
T_2 = T_1+25% N	86.51b	23.1bc	19.14	13.06	4.62b	102.36ab	20.3bc	20.69	14.39	5.06b
T_3 = T_1+25% NP	89.74b	27.4a	19.24	13.04	4.90ab	105.80ab	22.8ab	20.42	14.14	5.46ab
T_4 = T_1+25% NK	86.74b	23.1bc	19.28	13.10	5.04ab	102.63ab	20.4abc	20.48	14.26	6.08ab
T_5 = T_1+25% PK	88.39b	23.7b	19.28	13.18	5.08ab	103.00ab	21.5ab	20.42	14.42	5.98ab
T_6 = T_1+25% NPK	102.80a	29.9a	19.74	13.46	5.44a	115.60a	24.4a	20.60	14.39	6.43a
T_7 = 75% of T_1	69.31c	17.1d	19.03	13.06	3.69c	72.33c	1.73c	20.68	14.40	3.83c
T_8 = Control	44.31d	12.9e	19.20	13.22	2.40d	48.06d	8.1d	20.52	14.33	2.43d
CV(%)	5.84	854	4.38	5.61	9.20	9.98	11.03	4.37	5.69	10.48
SE (±)	2.739	1.09	0.487	0.426	0.238	5.362	1.23	0.518	0.471	0.307

T_1 = N_{47} P_{22} K_{34} S_5 Zn_1 kg ha^{-1} in cropping year 2011-12 and N_{46} P_{11} K_{36} S_{16} $Zn_{1.5}$ kg ha^{-1} cropping year 2012-13 for onion

Figure(s) in a column having same latter do not differ significantly as per DMRT at 5% level

Effects on soil properties

From the Table 4 and 5 it was showed that soil pH, available P, available S and available Zn content of the post-harvest soils slightly increased but, OC (%),total N content ,available K slightly decreased compared with initial soil due to application of fertilizers to the crops both the cropping year. Similar result was reported by Bokhtiar *et al.* (2012) and Paul *et al.*(2010) they observed that application of N, P, K, S & Zn as per recommended fertilizer dose increased soil pH and OC (%) but, decreased total N (%), available P (ppm) and exch. K (meq%) compared to the initial soil value.

Table 4. Effects of fertilizer applied in different combination on pH, OC and nutrient status of post harvest soils at Ishurdi during 2011-12 (site - 1)

Treatments	pH	OC (%)	Total N (%)	Available P (μgg^{-1})	Available K (meq%)	Available S (μgg^{-1})	Available Zn (μgg^{-1})
Initial soil	7.63	0.62	0.08	8.0	0.21	22.5	0.82
Post harvest soil							
T_1 = STB 100% NPKSZn	7.60	0.58	0.07	9.2	0.19	23.7	0.88
$T_2 = T_1$ + 25% N	7.65	0.59	0.07	9.0	0.18	23.6	0.88
$T_3 = T_1$ + 25% NP	7.62	0.58	0.07	9.7	0.19	23.0	0.86
$T_4 = T_1$ + 25% NK	7.70	0.60	0.07	8.9	0.20	23.3	0.86
$T_5 = T_1$ + 25% PK	7.63	0.58	0.07	10.0	0.19	23.6	0.87
$T_6 = T_1$ + 25% NPK	7.65	0.60	0.07	10.2	0.20	23.0	0.89
T_7 = 75% of T_1	7.60	0.57	0.07	7.9	0.18	21.9	0.80
T_8 = Control	7.60	0.55	0.06	6.9	0.17	21.0	0.73

Table 5. Effects of fertilizer applied in different combination on pH, OC and nutrient status of post harvest soils at Ishurdi during 2012-13 (site - 2)

Treatments	pH	OC (%)	Total N (%)	Available P (μgg^{-1})	Available K (meq%)	Available S (μgg^{-1})	Available Zn (μgg^{-1})
Initial soil	7.70	0.67	0.080	19.0	0.20	21.0	0.58
Post harvest soil							
T_1 = STB 100% NPKSZn	7.75	0.62	0.070	20.0	0.17	21.9	0.63
$T_2 = T_1$ + 25% N	7.73	0.65	0.075	20.2	0.17	21.8	0.62
$T_3 = T_1$ + 25% NP	7.72	0.60	0.070	21.4	0.17	22.0	0.60
$T_4 = T_1$ +25% NK	7.75	0.65	0.070	20.6	0.18	21.7	0.62
$T_5 = T_1$ + 25% PK	7.75	0.63	0.070	21.1	0.18	21.9	0.60
$T_6 = T_1$+25% NPK	7.75	0.65	0.075	21.5	0.19	21.5	0.65
T_7 = 75% of T_1	7.68	0.62	0.070	19.0	0.17	20.7	0.55
T_8 = Control	7.65	0.60	0.065	17.8	0.16	19.6	0.49

Economic analysis

The economic aspect of any fertilizer management package is important both for crop production and acceptance by the farmers. The cost and return analysis help in deciding the suitability of a fertilizer management package. From the economic analysis it was found that treatment T_6 gave the highest benefit cost ratio (BCR) by the application of 100% fertilizer on soil test value with additional 25% NPK for sugarcane and intercrop (onion) cultivation in the High Ganges River Flood plain (AEZ 11) soils of Bangladesh (Table 6). Chohan *et al*. (2013) observed that comparatively smaller cost benefit ratio was earned when P and K were lacking. Intercropping potato, onion, garlic and cabbage with sugarcane are always profitable compared to sole sugarcane and help to get extra benefit for the farmers (Haque *et al*., 2016; Alam, 2013; Alam *et al*., 2007).

Table 6. Economic analysis of fertilizer applied in different combination under sugarcane-onion intercropping system at Ishurdi

Treatments	Total production cost (Tk. ha^{-1})		Gross income (Tk. ha^{-1})		Net return (Tk. ha^{-1})		BCR	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
T_1	121146	118581	259684	298244	138538	179663	2.1	2.5
T_2	123533	120968	271126	316580	147593	195612	2.1	2.6
T_3	125623	122068	282324	329680	156701	207612	2.2	2.7
T_4	124553	122048	276324	327560	151771	205512	2.2	2.6
T_5	124256	120761	280214	327600	155956	206839	2.2	2.7
T_6	127815	124320	321680	364860	193865	240540	2.5	2.9
T_7	115094	113111	217106	226358	102012	113247	1.8	2.0
T_8	96605	96605	139206	149256	42601	52651	1.4	1.5

Price of fertilizer: Urea = Tk. 20 kg^{-1} ; TSP = Tk. 22 kg^{-1} ; MoP = Tk. 15 kg^{-1} ;gypsum = Tk. 10 kg^{-1} ; Zinc sulphate = Tk. 150 kg^{-1} ; Price of crops: Sugarcane: Tk. 2600 t^{-1}, Onion: Tk.16 kg^{-1}

In conclusion results revealed that, due to application of 25% additional NPK fertilizers along with the recommended doses of NPKSZn for sugarcane produced the highest yield benefits with a maximum benefit cost ratio. The same treatment had also significant positive effect on intercrop yield (onion). Thus, for achieving the optimum doses of nutrients for sugarcane + onion cropping patterns NPK fertilizers were applied 25% more with the recommended fertilizer dose and this findings may be included to update existing fertilizer recommendation guide.

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