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Integrated Nutrient Management on Productivity and Economics of Sugarcane under Three Agro-ecological Zones of Bangladesh

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Abstract: Field experiments were conducted to study the effects of integrated plant nutrient system (IPNS) on the yield and yield contributing parameters of sugarcane at Ishurdi, Thakurgaon and Sreepur under High Ganges River Flood plain, Old Himalayan Piedmont Plain and Madhupur Tract, respectively. The use of organic and inorganic fertilizer showed significant effect on the yield and yield attributes like tillers, millable stalk and juice quality of sugarcane. The results revealed that yield increase was to the extent of 22.86, 49.2 and 74.0 % at Ishurdi, Thakuragaon and Sreepur, respectively due to the application of 12.5 t ha^{-1} press mud/cowdung accompanying chemical fertilizers applied on the basis of soil test for HYG over present recommended rates of chemical fertilizer (as per FRG' 97) for MYG. Press mud alone increased 16-20 per cent cane yield over the dose of N, P, K, S, Zn and Mg fertilizers based on soil test for HYG at all locations. Incorporation of dhaincha (*Sesbania aculeata*) as green manure increased cane yield and contributed about 42-46 kg N ha^{-1} in soil.

Key words: Integrated nutrient management, productivity, economics, agro-ecological zone

Introduction

Sugarcane is the only source of white sugar in Bangladesh, cultivated on an area about 0.17 million hectares annually with an average yield of 41t ha^{-1}(BBS, 1998). Being a long duration and heavy feeder of nutrients it uptakes considerable amount of plant nutrients from soil. As a result, the nutrient ability of soil to supply plant nutrients is declining day by day which leads to decline productivity of sugarcane till recently. It is well agreed that a blend of organic and inorganic fertilizer can improve the cane production besides maintaining the soil health.

Rabindra *et al*. (1990) reported that continuous application of farmyard manure (FYM) along with NPK fertilizer improves physico-chemical properties of soil, cane yield and juice quality. Press mud is an organic by product of sugar mills and one ton of millable cane gives about 30 kg of press mud (Quilloy, 1974). It is a rich source of organic carbon (35-37%) and supplies 1.0-1.5 % N, 2.5-3.5% P_2O_5 and 0.3-0.8 % K_2O. Besides, it is a good source of micro-nutrient and qualities to amend the soil nature. It is also reported that the slow decomposition of press mud may benefit the ratoon cane (Kale, 1981). So, considering the above facts a study was conducted with the following objectives:

a) to evaluate the fertility status of soil by using organic and inorganic fertilizer, b) to improve soil health through IPNS for sustainable sugarcane production and c) to study the productivity and profitability of different fertilizer management packages.

Materials and Methods

Three field experiments were conducted in 1999-2000 cropping season at Ishurdi, Thakurgaon and Sreepur site under High Ganges River Flood plain, Old Himalayan Piedmont Plain and Madhupur Tract, respectively. The soil of Ishurdi site was calcareous in nature, near to neutral in reaction and deficient in organic matter, nitrogen, phosphorus, sulphur and zinc. Potassium was near to critical level. The Thakurghaon and Sreepur soils are non-calcareous, acidic in reaction, low in available nitrogen, potassium and medium in available phosphorus. Sulphur was quite adequate and low in zinc (Table 2). Experiments were laid out in randomized complete block design with four replications. The unit plot size was 8x6m^2. Two budded soil bed settlings of variety Isd 26 and Misrimala (local) were used as test material at Ishurdi and Sreepur site, respectively. Thirty-five days-aged poly bag settlings of Isd 28 were used as seed material at Thakurgaon site. All the recommended cultural management practices were followed when required. N as urea and P as MP were applied in three splits; first at 20-30 days after transplanting, second at peak tillering stage and finally one month after second top dressing. Full amount of TSP, Gypsum, Zinc sulphate, MgO and organic fertilizers were applied in the trenches and mixed thoroughly with soil by spade. Cowdung was used only at Sreepur site. Dhaincha as green manure were raised and incorporated *in situ* after 50 ± 5 days of seed sowing. The N, P and K contents of cowdung and press mud were 0.78, 0.10 and 0.50 and 0.55, 0.15 and 0.20 per cent respectively. The N, P and K contents of mustard oil cake and green manure were 3.5, 1.4 and 1.3 and 1.24, 0.02 and 0.3 percent respectively. The incorporated green manure Dhaincha contained 1.65 % N. Necessary data were recorded and analyzed using the Least Significant Differences Test (LSD) at P=0.05. Economics of different treatments were calculated on the basis prevailing market prices during the study period. Sugarcane crop was harvested 13 months after planting. Initial soils at the depth of 0-15 cm were collected and analyzed following the standard procedure. The treatment wise different rates of organic and inorganic fertilizer of different locations are presented in Table 1. The treatments are as follows:

T_0: Control
T_1: Recommended fertilizer rate (as per FRG' 97) for MYG
T_2: 12.5t ha^{-1} press mud/ cowdung + T_1
T_3: Fertilizer rate based on soil test value for HYG
T_4: 12.5t ha^{-1} press mud/ cowdung + T_3
T_5: GM (dhaincha) + T_3
T_6: 500Kg MOC + T_3

FRG = Fertilizer Recommendation Guide, 1997; MYG = Moderate Yield Goal (80 ± 10 t ha^{-1}) ; HYG = High Yield Goal (100 ± 10 t ha^{-1}) ; MOC = Mustard Oil Cake

Results and Discussion

Yield attributes and yield

High Ganges River Flood plain (Ishurdi site): The effects of organic and inorganic fertilizers on tiller, millable cane stalks, yield and brix (%) are presented in the Table 3a. Significantly lowest number of tillers (161.7x10^3 ha^{-1}), millable cane stalks (96.0x10^3 ha^{-1}) and yield (67.3 t ha^{-1}) of cane were obtained from the control (T_0), while the highest number of tillers (212.2 x 10^3 ha^{-1}), millable cane stalks (151.3 x 10^3 ha^{-1}), yield (127.5t ha^{-1}) and brix (20.58 %) were obtained from T_4 combination which received 12.5 t ha^{-1} press mud with chemical fertilizers based on soil test value for HYG. The cane yield increased at T_6, T_5, T_4, T_3, T_2 and T_1 was 65.69, 75.28, 89.33, 60.92, 71.56 and 54.11 %, respectively compared with control, respectively. Addition of different organic manures increased yield about 2.9, 8.9 and 17.65% at T_6, T_5, and T_4 compared with T_3 (only chemical fertilizers were applied on soil test value for HYG). From the above study it was noticed that addition of organic manure/green manure with chemical fertilizers produced higher cane yield as compared with treatments where

Table 1: Amount of nutrients (kg ha^{-1}) used in different treatments in the experimental sites

Treatments		Ishurdi							
		N	P	K	S	Zn	Mg	Press Mud	MOC
T_0:	Control	-	-	-	-	-	-	-	-
T_1:	Recommended fertilizer rate (as per FRG' 97) for MYG	130	25	60	20	3	-	-	-
*T_2:	12.5t ha^{-1} press Mud + T_1	90	25	45	20	3	-	12,500	-
T_3:	Fertilizer rate based on soil test for HYG	203	72	120	28	4	-	-	-
*T_4:	12.5t ha^{-1} Press Mud + T_3	163	62	105	28	4	-	12,500	-
*T_5:	GM (Dhaincha) + T_3	178	67	110	28	4	-	-	-
*T_6:	500Kg MOC + T_3	190	67	115	28	4	-	-	500
Treatments		Thakurgaon							
		N	P	K	S	Zn	Mg	Press Mud	MOC
T_0:	Control	-	-	-	-	-	-	-	-
T_1:	Recommended fertilizer rate (as per FRG' 97) for MYG	120	35	100	25	2	15	-	-
*T_2:	12.5t ha^{-1} press Mud + T_1	80	25	85	25	2	20	12,500	-
T_3:	Fertilizer rate based on soil test for HYG	190	40	133	33	3	20	-	-
*T_4:	12.5t ha^{-1} Press Mud + T_3	150	30	118	33	3	20	12,500	-
*T_5:	GM (Dhaincha) + T_3	165	35	123	33	3	20	-	-
*T_6:	500Kg MOC + T_3	177	35	128	33	4	20	-	500
Treatments		Sreepur							
		N	P	K	S	Zn	Mg	Cowdung	MOC
T_0:	Control		-	-	-	-	-	-	--
T_1:	Recommended fertilizer rate (as per FRG' 97) for MYG	120	40	100	30	2	10	-	-
*T_2:	12.5t ha^{-1} cowdung + T_1	80	30	85	30	2	10	12500	-
T_3:	Fertilizer rate based on soil test for HYG	196	26	104	24	2	10	-	-
*T_4:	12.5t ha^{-1} cowdung + T_3	156	16	89	24	2	10	12500	-
*T_5:	GM (Dhaincha) + T_3	171	21	94	24	2	10	-	-
*T_6:	500Kg MOC + T_3	183	21	99	24	2	10	-	500

*Quantity of N, P, K and S derived from organic sources were adjusted to T_2, T_4, T_5 and T_6 keeping the chemical fertilizer dose same

Table 2: Initial and final soil status of the experimental sites of different fertilizer packages for sugarcane at different sites

Sites	Treatments	Analytical value						
		pH	OM (%)	N (%)	P (ppm)	K (meq/100g soil)	S (ppm)	Zn (ppm)
Ishurdi	Initial	7.5	1.09	0.07	9.0	0.18	16.0	1.67
	Final							
	T_0	7.6	1.05	0.06	8.5	0.18	15.0	-
	T_1	7.8	1.00	0.065	8.0	0.18	14.0	-
	T_2	7.7	1.06	0.06	8.0	0.18	14.5	-
	T_3	7.6	0.99	0.07	9.0	0.19	14.0	-
	T_4	7.6	1.01	0.065	9.0	0.19	15.0	-
	T_5	7.8	1.05	0.07	8.5	0.18	15.0	-
	T_6	7.7	1.06	0.07	8.0	0.17	14.0	-
Thakurgaon	Initial	5.3	1.88	0.10	20.0	0.21	20.0	1.0
	Final							
	T_0	5.2	1.90	0.09	21.0	0.19	24.0	-
	T_1	5.0	1.98	0.10	20.0	0.20	23.0	-
	T_2	5.1	1.95	0.09	22.0	0.20	23.0	-
	T_3	5.2	1.97	0.08	21.0	0.19	22.0	-
	T_4	5.3	2.12	0.09	21.0	0.21	23.0	-
	T_5	5.4	2.01	0.10	22.0	0.20	22.0	-
	T_6	5.2	1.99	0.08	21.0	0.20	21.0	-
Sreepur	Initial	5.4	1.61	0.10	20.0	0.23	37.0	1.0
	Final							
	T_0	5.1	1.6	0.09	17.0	0.22	35.0	-
	T_1	4.9	1.8	0.08	15.0	0.21	34.0	-
	T_2	5.2	1.65	0.09	16.0	0.21	36.0	-
	T_3	5.4	1.75	0.09	15.0	0.22	35.0	-
	T_4	5.0	1.70	0.10	16.0	0.23	37.0	-
	T_5	5.0	1.65	0.09	17.0	0.22	35.0	-
	T_6	5.1	1.60	0.08	16.0	0.21	36.0	-

- Indicates not available.

Table 3a: Yield and yield attributes of sugarcane as influenced by IPNS at Ishurdi [Figures with same letter do not differ significantly at 5 % level as per DNMR test]

Treatments	Tillers (x10^3 ha^{-1})	Millable cane stalks (x10^3 ha^{-1})	Yield of cane (t ha^{-1})	Dry matter of dhaincha (t ha^{-1})	Brix (%)
T_0	161.70 b	96.04 d	67.34 f	-	19.80 d
T_1	208.93 a	128.27 bc	103.78 e	-	20.42 ab
T_2	206.00 a	119.44 c	115.53 bc	-	19.93 cd
T_3	195.18 a	133.93 b	108.37 de	-	20.19 bc
T_4	212.15 a	151.34 a	127.50 a	-	20.58 a
T_5	207.90 a	132.20 b	118.04 b	2.82	20.13 bc
T_6	208.84a	144.08 a	111.58	-	20.34 ab

Table 3b: Yield and yield attributes of sugarcane as influenced by IPNS at Thakurgaon

Treatments	Tillers (x 10^3 ha^{-1})	Millable cane stalks (x10^3 ha^{-1})	Yield of cane (t ha^{-1})	Dry matter of dhaincha (t ha^{-1})	Brix (%)
T_0	107.55b	72.65d	55.18c	-	19.18
T_1	183.20a	93.85c	80.19b	-	18.91
T_2	197.88a	102.60c	88.55b	-	18.94
T_3	193.22a	126.03ab	102.04b	-	18.94
T_4	190.56a	134.76a	119.64a	-	18.69
T_5	191.40a	115.57b	99.57ab	1.89	18.79
T_6	188.90a	103.04c	87.31b	-	19.24

Table 3c: Yield and yield attributes of sugarcane as influenced by IPNS at Sreepur

Treatments	Tillers (x 10^3 ha^{-1})	Millable cane stalks (x10^3 ha^{-1})	Yield of cane (t ha^{-1})	Dry matter of dhaincha (t ha^{-1})	Brix (%)
T_0	79.40c	65.20b	55.05d	-	19.08
T_1	132.60b	72.46b	71.73c	-	19.79
T_2	143.13a	90.43a	99.57b	-	19.86
T_3	131.76b	91.67a	105.69ab	-	19.84
T_4	145.64a	96.47a	124.83a	-	19.50
T_5	126.28b	88.80a	121.66ab	2.12	19.65
T_6	132.46b	91.18a	101.41b	-	19.70

Table 4a: Economic analysis of different fertilizer management packages of sugarcane through IPNS at Ishurdi

Treatment	Yield of cane (t ha^{-1})	Fertilizer cost (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Return Tk. ha^{-1} (cane + trash)	Net profit (Tk. ha^{-1})	Benefit cost ratio (BCR)
T_0	67.34	-	23,200	68,956	45,756	2.97
T_1	103.78	5,899	29,099	1,06,270	77,171	3.65
T_2	115.53	6,941	30,141	1,18,302	88,161	3.92
T_3	108.37	10,698	33,898	1,10,971	77,073	3.27
T_4	127.50	11,738	34,938	1,30,560	95,622	3.73
T_5	118.04	10,257	33,457	1,20,872	87,415	3.61
T_6	111.58	13,605	36,805	1,14,258	77,453	3.10

Table 4b: Economic analysis of different fertilizer management packages of sugarcane through IPNS at Thakurgaon.

Treatment	Yield of cane (t ha^{-1})	Fertilizer cost (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Return Tk. ha^{-1} (cane + trash)	Net profit (Tk. ha^{-1})	Benefit cost ratio (BCR)
T_0	55.18	-	21,800	56,504	34,704	2.59
T_1	80.19	9,195	30,995	82,110	51,115	2.64
T_2	88.55	10,850	32,650	90,675	58,025	2.78
T_3	102.04	11,942	33,742	1,04,448	70,746	3.09
T_4	119.64	12.883	34,683	1,22,510	87,827	3.53
T_5	99.57	11,502	33,300	1,01,959	68,659	3.06
T_6	87.31	14,964	36,764	89,419	52,655	2.43

Table 4c: Economic analysis of different fertilizer management packages of sugarcane through IPNS at Sreepur

Treatment	Yield of cane (t ha^{-1})	Fertilizer cost (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Return Tk. ha^{-1} (cane + trash)	Net profit (Tk. ha^{-1})	Benefit cost ratio (BCR)
T_0	55.05	-	23,200	56,370	33,170	2.43
T_1	71.73	8,800	32,000	73,450	41,450	2.28
T_2	99.57	9,600	33,400	1,01,959	71,559	3.05
T_3	105.69	8,600	31,800	1,08,227	76,427	3.40
T_4	124.83	9,650	32,850	1,27,825	94,975	3.89
T_5	121.66	8,150	31,350	1,24,580	93,230	3.97
T_6	101.41	11,500	34,700	1,03,845	69,145	2.99

Price of input and output and labour wages was considered on local market

only chemical fertilizers were used. It is expected that use of organic manures in the soil, had a positive effect on cane yield and soil properties as well. Singh *et al.* (1995) reported that press mud alone or in combination with nitrogen improved the cane yield and quality of plant and ratoon crops.

Old Himalayan Piedmont plain (Thakurgaon site): Data on tillers, millable cane stalks and yield were significantly influenced by the application of fertilizer through integrated plant nutrient system (IPNS) and are shown in Table 3b. The highest number of tillers of 197.9 x 10^3 ha^{-1} was produced at T_2 treatment followed by T_3 treatment while the lowest number of 107.6 x10^3 ha^{-1} was produced for T_0 (control) treatment. Highest number of millable cane stalks (134.8 x10^3 ha^{-1}) and cane yield (119.6 t ha^{-1}) were obtained with the application of 12.5 t ha^{-1} press mud with chemical fertilizers based on soil test value for HYG (T_4) which was similar to T_3 and T_5 treatments. The average yield increase at T_4 was 116.8, 49.2, 35.1 and 17.2 % compared with T_0, T_1, T_2, and T_3, respectively. The yield increase was superior with those treatments where a blend of organic and inorganic fertilizer was applied. Significant effect was not observed in brix per cent of cane juice.

Madhupur Tract (Sreepur site): Sugarcane yield and its components, viz. tillers, millable cane stalks were significantly influenced by the application of different levels of organic and inorganic fertilizers (Table 3c). The highest number of tillers (145.6 x1 0^3 ha^{-1}) millable cane stalks (96.5 x 10^3 ha^{-1}) and higher cane yield (121.7 t ha^{-1}) were produced at T_4 treatment, where 12.5 t ha^{-1} cowdung with chemical fertilizers based on soil test value for HYG was applied. The increase in cane yield at T_4 was 126.6, 74.0, 25.4 and 18.1 % compared with T_0, T_1, T_2 and T_3 treatment. At Ishurdi and Thakurgaon site, comparatively higher yields were also found with the application of organic and inorganic fertilizers. Brix percent was not significantly differed among the treatments.

Soil fertility status: The status of soil pH, organic carbon, total N, available P, K, S and Zn in initial soil as well as post harvest soil of one cycle of sugarcane are presented in Table 2. No perceptible changes were observed in soil characteristics due to the use of varying fertilizer packages. The application of green manure, press mud or cowdung brought some increase in soil organic matter at Thakurgaon and Sreepur. Bokhtiar *et al.* (2001) and Islam *et al.* (1998) obtained similar results. The changes in total N, available P, K and S in soil were not conspicuous.

Economics of fertilizer use: Farmers' of our country are continuously facing multifarious problems in crop production and strongly considered the economics of fertilizer use by which they can benefited. Hence an economics of different fertilizer management packages of Ishurdi, Thakurgaon and Sreepur site are presented in the Tables 4a 4b & 4c, respectively. An economic analysis of different fertilizer packages was done considering the total variable cost and return where all other costs involved were same for all the treatments. At different sites the highest net benefit and BCR varied, as it was associated with the yield production as well as fertilizer requirement in the treatments. At Ishurdi, the highest BCR of Tk. 3.92 was obtained in T_2 treatment followed by Tk. 3.73 in T_4 treatment with highest net benefit. At Thakurgaon, the highest net benefit and BCR of Tk. 3.53 was found in T_4 treatment followed by Tk. 3.09 in T_3 and Tk. 3.06 in T_5. At Sreepur, the highest BCR of Tk. 3.97 was found in T_5 treatment, which was close to T_4 treatment (3.89) with highest net benefit.

Use of 12.5 t ha^{-1} press mud/cowdung with chemical fertilizers based on soil test value for high yield goal may be suggested for maximizing sugarcane production and achieving higher economic benefit. In situ green manure incorporation increased sugarcane yield and supplemented about 42 to 46 kg N ha^{-1} in the subsequent cane crop as well. The application of press mud, cowdung, mustard oil cake and green manure should be incorporated in soil to maintain soil fertility for sustainable sugarcane production.

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