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Integrated use of organic and inorganic fertilizer for sugarcane cultivation in active Tista floodplain soils

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ABSTRACT

An experiment was conducted in the farmers' field of two locations, one at Mahimaganj, Gaibandha and other at Shyampur, Rangpur, under active Tista floodplain (AEZ II) in Bangladesh during 2019-2020 cropping season to know the performance of sugarcane applying organic manure pressmud/poultry litter with inorganic fertilizer. There were eight treatment combinations in the study. The overall results under this study indicated that most of the observed parameters showed significant differences except brix (%) in both locations. Among all treatment combinations, 100% recommended organic fertilizer dose plus pressmud 10 tha^{-1} was given the highest cane yield (94.13 tha^{-1} and 83.33 tha^{-1}) and benefit cost ratio (2.26 and 2.00) in both locations. Considering the total cost and economic return, different factors associated with production system and farmers' liking of sugarcane cultivation might be a profitable package of integrated use of organic manure and inorganic fertilizer for sugarcane cultivation at Active Tista Floodplain soils.

***Key Words**: Sugarcane, Manure, Fertilizer, Yield and Benefit cost ratio.*

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I. Introduction

Sugarcane (*Saccharum officinarum* L.) is a perennial crop that can be used for animal feed as well as sugar production. The individual and combined effects of certain management practices, such as planting date, row spacing, planting depth, fertilizer rate, pest control and irrigation, have a significant impact on the growth and yield of sugarcane. Most soils in Bangladesh are low in organic matter (OM), generally containing 1.5% OM, while 2.5 to 3.0% OM is necessary for sustainable crop production. Because of its large biomass yield and long growth period, sugarcane requires a considerable amount

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of plant nutrients for its vegetative growth and development. Due to significant depletion of soil nutrients, sugarcane soils become less fertile and fail to produce higher yields (Bokhtiar et al., 2015). Although chemical fertilizers have been claimed as the most important contributor to the increase in world agricultural productivity over the past decades (Smil, 2001) but long-term fertilization causes declines in soil quality and crop yield, hindering current agricultural development (Wang et al., 2019). Integrated nutrient management (INM) aims to maintain or adjust soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of benefits from all possible sources of plant nutrients in an integrated manner (Kannan et al., 2013). Composting of pressmud and poultry litter with mineral fertilizers to improve their chemical and physical characteristics. (Chen and Jiang, 2014).

Organic waste such as pressmud or filter cake is a by-product of sugar factories which is utilized to provide a nutrient rich, high quality organic matter when applied to the soil as manure results in better sustainable yield. It is soft, spongy, amorphous and dark brown white material containing nitrogen, cellulose, lignin, protein, sugar fiber and coagulated colloids, including cane wax, albuminoids, inorganic salts and soil particles and all other carbon containing components available in the final product (Joshi and Sharma, 2010). It usually contains about 70% lime and 15-20% organic (Khattak and Khan, 2004). The organic fraction of PM is 15-30% fiber, 5-15% crude protein, 5-15% sugar, 5-15% crude wax and fats and 10-20% ash comprising oxides of Si, Ca, P, Mg and K (Partha and Sivasubramanian, 2006). It is reported to be a valuable resource of plant nutrients and affects physical, chemical and biological properties of soil (Muhammad and Khattak, 2009). Organic material such as poultry litter is a mixture of substrate, feces, feathers and feed scraps used in bedding of broiler sheds (Chen et al., 2013). It is usually recycled as an organic fertilizer or soil amendment to provide plant nutrients and organic matter to the soil required for growth and yield (Roy et al., 2015). Besides that, their use in agriculture as an alternative source of nutrients is important both to properly dispose of these products in order to avoid environmental pollution and to reduce high costs of synthetic fertilizers (Portugal et al., 2009). Sufficient and balanced application of organic and inorganic fertilizers is a significant component of integrated nutrient management (Srivastava et al., 2015). Integrated uses of chemical and organic fertilizers are found to be more beneficial for sustainable sugarcane production. The combined use of organic and inorganic fertilizers gave significantly higher sugarcane yield and economic benefits (Paul et al., 2007). Considering this fact, this study was undertaken to develop suitable packages of integrated use of organic manure and inorganic fertilizer for sugarcane cultivation at active Tista Floodplain soils.

II. Materials and Methods

The experiment was conducted at farmers' fields at Mahimaganj, Gaibandha and Shyampur, Rangpur of Bangladesh, during 2019-2020 cropping season under irrigated conditions. The site represents the active Tista floodplain (Agro-Ecological Zone II) with medium-high land of typical sandy loam soil with a pH of 5.40. The experiment was laid out in a Randomized Complete Block Design with three replications. The unit plot size was 8m × 6m with the following treatment combinations.

T_1 : Control (no fertilizer and manure)
T_2 : RFD (Recommendation Fertilizer Dose)
T_3 : 100% RFD + Pressmud 10 t ha^{-1}
T_4 : 75 % RFD + Pressmud 10 t ha^{-1}
T_5 : 75 % RFD + Pressmud 10 t ha^{-1} + Poultry litter 5 t ha^{-1}
T_6 : 50 % RFD + Pressmud 10 t ha^{-1} + Poultry litter 5 t ha^{-1}
T_7 : 100 % RFD + Poultry litter 5 t ha^{-1}
T_8 : 75% RFD + Pressmud 5 t ha^{-1} + Poultry litter 5 t ha^{-1}

Two budded setts of sugarcane variety Isd 39 were used as planting material and planted in rows 100cm apart with end to end placement. The setts were planted on 20th December, 2019 in both locations. The inter-row spacing between two cane rows was tilth well by spade and country plough. Fertilizers were applied as per recommended rate from fertilizer recommendation guide (BARC, 2012). Urea, TSP, MOP, Gypsum and ZnSO4 were applied at rates of 358, 275, 240, 188 and 7kg ha^{-1}, respectively, for cane planting, with the entire quantity of TSP, Gypsum, ZnSO4 and a third of Urea and MoP placed in trench and mixed with soil prior to planting setts. In terms of treatment, organic

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manure of pressmud and poultry litter was integrated into the soil with basal fertilizer application. The second dose of Urea (1/3rd) and MoP (1/3rd) was applied as first top dressing (at 90 DAP) and final top dressing was done with the rest amount of Urea and MoP at 150 DAP. Fripronil 3% GR was applied between two ridges @ 33 kg/ha for controlling termite at planting time. Cabofuran 5 G @18 kg/ha was applied twice, 90 DAP and 150 DAP, during earthing up for controlling borer pest. A total of four irrigations were given. First irrigation was given 15 days after setts planting and other three irrigations were given 45 days interval. Necessary intercultural operations like weeding, mulching, gap filling, tying etc., were done accordingly. Pre-sowing irrigation was given to ensure the maximum germination percentage. Soil samples were collected from 0-15 cm dept before plantation and after sugarcane harvesting and analyzed following standard procedures. Tiller population was counted at 150 DAP. Millable cane, stalk height, stalk diameter and cane yield were counted at harvest time. The samples were collected from the area of 25 m^2 of each plot, avoiding the border plants and then converted to hector. After harvested crop, only stalk were weighted by the weight machine. Brix (%) of cane was randomly recorded by refract meter from five canes in each plot at harvest time. Sugarcane was harvested in Mid December of 2020 in both locations. Fisher's analysis of variance (ANOVA) was used for statistical analysis of collected data and comparison of differences among treatment means. Least significant difference (LSD) test was used at 5% probability. Statistics 10 (Tallahassee FL 32317) was used to determine statistical deference.

Benefit cost ratio indicated whether the cultivation was profitable or not, which was calculated as follows (CIMMYT, 1988):

$$BCR = \frac{\text{Gross return (Tk.ha}^{-1})}{\text{Cost of production (Tk.ha}^{-1})}$$

Gross return = Value of cane
Cost of production = Sum of the cost of the resources.

III. Results and Discussion

Tiller population

Tillering potentiality of sugarcane ultimately affects cane yield positively (Table 01). The maximum tiller population of 166.62 × 10^3 ha^{-1} and 198.74 × 10^3 ha^{-1} was found from the treatment T_7 at Gaibandha and Rangpur locations, respectively. The minimum number of tillers 98.12 × 10^3 ha^{-1} and 116.31 × 10^3 ha^{-1} was found from the treatment T_1 at Gaibandha and Rangpur locations, respectively. A similar result was observed by Hossain et al. (2009). They observed maximum tiller production (183.1 62x 10^3) from recommended fertilizer with pressmud @ 5 t ha^{-1}.

Table 01. Performance of tiller, millable cane and Brix (%) of sugarcane at both locations

Treatments	Tiller (×10^3 ha^{-1})		Millable cane (×10^3 ha^{-1})		Brix (%)	
	Gaibandha	Rangpur	Gaibandha	Rangpur	Gaibandha	Rangpur
T_1	98.12 c	116.31 d	66.25 b	57.13 c	22.20	21.50
T_2	160.00 a	181.66 abc	75.62 ab	76.76 ab	21.80	20.40
T_3	126.99 b	177.00 abc	74.23 ab	69.00 b	22.20	21.00
T_4	145.66 ab	175.33 bc	79.56 a	71.63 ab	21.70	20.30
T_5	146.64 ab	178.66 abc	74.00 ab	80.53 ab	22.20	20.60
T_6	161.33 a	197.66 ab	74.62 ab	87.50 a	21.60	20.70
T_7	166.62 a	198.74 a	76.61 ab	80.00 ab	22.20	21.20
T_8	160.66 a	170.66 c	87.43 a	82.54 ab	22.30	20.80
LSD (0.05)	20.56	24.39	13.04	14.01	NS	NS

In a column, figures with similar letters do not differ significantly at 5% level

Here, T_1: Control (no fertilizer and manure), T_2: RFD (Recommendation Fertilizer Dose), T_3: 100% RFD + Pressmud 10 t ha^{-1}, T_4: 75 % RFD + Pressmud 10 t ha^{-1}, T_5: 75 % RFD + Pressmud 10 t ha^{-1} + Poultry litter 5 t ha^{-1}, T_6: 50 % RFD + Pressmud 10 t ha^{-1} + Poultry litter 5 t ha^{-1}, T_6: 50 % RFD + Pressmud 10 t ha^{-1} + Poultry litter 5 t ha^{-1}, T_7: 100 % RFD + Poultry litter 5 t ha^{-1}, T_8: 75% RFD + Pressmud 5 t ha^{-1} + Poultry litter 5 t ha^{-1}.

Millable cane

The number of millable cane directly influences cane yield. The highest number of millable cane of 87.43 × 10^3 ha^{-1} was found from the treatment T_8 at Gaibandha location. At Rangpur, highest number of millable cane of 87.50 × 10^3 ha^{-1} was found from the treatment T_6. The lowest number of millable cane of 66.25 x 10^3 ha^{-1} and 57.13 x 10^3 ha^{-1} were found from T_1 at Gaibandha and Rangpur locations, respectively (Table 01). A similar result was observed by Bokhtiar et al. (2015).

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Brix (%)

Brix readings obtained from all the treatments were not significantly affected but were numerically different (Table 01). The range of the Brix % (22.30 – 21.60) was found at Gaibandha location. At Rangpur location, brix (%) was found (21.50 – 20.30). A similar result was in agreement with Hossain et al. (2009). They found that brix (%) of sugarcane did not significantly differ by the combined application of organic fertilizer with inorganic fertilizer.

Stalk height

Environmental factors and genetic characteristics of plants play an important role in determining the plant height. The highest Stalk height 3.40 m and 3.34 m were found from the treatment T_3 in both locations. The lowest cane stalk heights 2.77 m and 2.73 m were found from the T_1 in both locations (Table 02). The findings confirm with the results of Bokhtiar et al. (2015). They found that combined application of pressmud with chemical fertilizers improved the application of pressmud 7.5 t ha^{-1} with inorganic fertilizer had some beneficial effects on cane length and the effect was also statistically significant. Application of 7.5 t ha^{-1} pressmud plus 100% RFD produced the tallest cane (3.897 m).

Stalk diameter

The highest Stalk diameters 2.23 cm and 2.21 cm were found from the treatment T_3 in both locations. The lowest cane Stalk diameters 1.73 cm and 1.68 cm were found from the T_1 in both locations (Table 02). Similar findings were in agreement with Bokhtiar et al. (2015). They found that cane girth was significantly affected by combined application of pressmud with chemical fertilizers among different treatments.

Cane yield

The highest cane yield 96.21 t ha^{-1} and 83.25 t ha^{-1} were found from the treatment T_3 in both locations. The lowest cane yield was 51.17 t ha^{-1} and 45.10 t ha^{-1} found from T_1 in both locations (Table 02). A similar result was in agreement with Bokhtiar et al. (2015). They showed that combined application of pressmud with chemical fertilizers improved the cane yield and the effect was more pronounced at higher fertilizer levels (100% RFD).

Table 02. Performance of stalk height, diameter and cane yield of sugarcane at both locations

Treatments	Stalk height (cm)		Stalk diameter (m)		Cane yield(t ha^{-1})	
	Gaibandha	Rangpur	Gaibandha	Rangpur	Gaibandha	Rangpur
T_1	2.77 f	1.73 d	2.72 d	1.68 c	51.17 d	45.10 c
T_2	3.30 b	2.12 b	3.19 abc	2.10 ab	79.00 bc	76.43 ab
T_3	3.40 a	2.23 a	3.34 abc	2.21 ab	96.21 a	83.25 a
T_4	3.15 de	2.00 c	3.10 c	2.10 ab	83.32 abc	73.80 b
T_5	3.21 c	2.10 b	3.15 bc	2.14 ab	76.33 c	77.93 ab
T_6	3.23 c	2.15 ab	3.22 a	2.15 a	80.10 bc	78.56 ab
T_7	3.20 cd	2.08 b	3.11 bc	2.00 b	84.26 abc	75.41 ab
T_8	3.10 e	2.11 b	3.28 ab	2.12 ab	81.66 ab	77.00 ab
lsd (0.05)	0.05	0.08	0.17	0.14	14.06	8.60

In a column, figures with similar letters do not differ significantly at 5% level

Here, T_1: Control (no fertilizer and manure), T_2: RFD (Recommendation Fertilizer Dose), T_3: 100% RFD + Pressmud 10 t ha^{-1}, T_4: 75 % RFD + Pressmud 10 t ha^{-1}, T_5: 75 % RFD + Pressmud 10 t ha^{-1} + Poultry litter 5 t ha^{-1}, T_6: 50 % RFD + Pressmud 10 t ha^{-1} + Poultry litter 5 t ha^{-1}, T_6: 50 % RFD + Pressmud 10 t ha^{-1} + Poultry litter 5 t ha^{-1}, T_7: 100 % RFD + Poultry litter 5 t ha^{-1}, T_8: 75% RFD + Pressmud 5 t ha^{-1} + Poultry litter 5 t ha^{-1}.

Economics

The economic analysis of the experiment under different treatment combinations are presented in Table 03. Among the different treatments, the highest gross return (235325.00 Tk.ha^{-1}) and (208325.00 Tk.ha^{-1}) were achieved from T_3 in both locations. The lowest gross return of 125000.00 Tk.ha^{-1} and 107500.00 Tk.ha^{-1} were calculated from the treatment T_1 in both locations. The highest net return (131325.00 Tk.ha^{-1}) and (104325.00 Tk.ha^{-1}) were achieved from T_3 in both locations. The lowest net return of 38080.00 Tk.ha^{-1} and 20580.00 Tk.ha^{-1} was found from the treatment T_1 in both locations. The treatment T_3 was given the highest BCR of 2.26 and 2.00 in both locations and the lowest BCR of 1.44 and 1.24 were given the treatment T_1 in both locations. A similar result was

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observed by Hossain et al. (2009). They observed that recommend dose with pressmud @5 t ha^{-1} give the highest gross margin (112593.00 Tk.) and BCR 2.92.

Table 03. Total cost of production, gross return, net return and benefit cost ratio of sugarcane in both locations.

Treatments	Total cost of production cost (Tk.ha^{-1})		Gross return (Tk.ha^{-1})		Net return (Tk.ha^{-1})		Benefit cost ratio (BCR)	
	Gaibandha	Rangpur	Gaibandha	Rangpur	Gaibandha	Rangpur	Gaibandha	Rangpur
T_1	86920	86920	125000	107500	38080	20580	1.44	1.24
T_2	1,01,000	1,01,000	197500	189150	96500	88150	1.95	1.87
T_3	1,04,000	1,04,000	235325	208325	131325	104325	2.26	2.00
T_4	1,02,480	1,02,480	208325	185000	105845	82520	1.98	1.80
T_5	1,12,480	1,12,480	190825	195825	78345	83345	1.70	1.74
T_6	1,16,000	1,16,000	197500	196650	181500	80650	1.70	1.70
T_7	107480	107480	210650	188325	103170	80845	1.95	1.75
T_8	108960	108960	201650	187500	92690	78540	1.85	1.72

Price ofsugarcane: 2500 Tk.ha^{-1}, Price of fertilizer and organic manure: Urea = 16 Tk.kg^{-1}, TSP = 22 Tk.kg^{-1}, MoP =15 Tk.kg^{-1}, Gypsum = 8 Tk.kg^{-1}, Zincsulphate = 160 Tk.kg^{-1}, Pressmud = 0.5 Tk.kg^{-1}, Poultry litter = 2 Tk.kg^{-1}

Soil nutrient status

Table 04 shows that the soil pH, organic C and S contents increased slightly over initial value in the plot of all treatments except treatment T_1 (no fertilizer and manure) at both locations. N improved slightly over initial soil except for T_8, T_7 and T_1 at Gaibandha. On the other hand, N slightly increased in treatments T_6, T_3 and T_2 but decreased in the treatment T_8, T_7, T_6 and T_2 at Rangpur location. P and K content in the soil slightly increased after sugarcane harvest compared to the initial soil in all treatments except T_1 at both locations. A similar result was reported by Haque et al. (2011). They reported that applying different treatments with organic and inorganic fertilizers slightly improved soil nutrient soil pH, OC %, P, K, S except for N contents of soils after sugarcane harvesting.

Table 04. Nutrient status of initial and post harvest soil of the experimental site as affected by different fertilizer management options for sugarcane at both locations

Treatments	pH		OC (%)		S (mg kg^{-1})		N (%)		P (mgkg^{-1})		K (cmolkg^{-1})	
	Gaibandha	Rangpur	Gaibandha	Rangpur	Gaibandha	Rangpur	Gaibandha	Rangpur	Gaibandha	Rangpur	Gaibandha	Rangpur
Initial soil	5.40	5.15	1.09	1.15	18	16	0.075	0.073	16	14	0.17	0.19
Post harvest soil												
T_1	5.10	5.00	1.00	1.10	16	15	0.069	0.067	15	14	0.16	0.17
T_2	5.40	5.30	1.00	1.16	19	18	0.076	0.074	17	15	0.18	0.20
T_3	5.45	5.25	1.20	1.25	20	20	0.079	0.077	18	16	0.18	0.20
T_4	5.35	5.20	1.20	1.30	17	16	0.076	0.070	17	15	0.19	0.17
T_5	5.60	5.35	1.25	1.30	17	17	0.078	0.072	18	18	0.18	0.17
T_6	5.50	5.15	1.30	1.32	20	19	0.079	0.078	19	18	0.19	0.21
T_7	5.35	5.20	1.10	1.20	18	16	0.070	0.069	17	16	0.17	0.20
T_8	5.45	5.30	1.25	1.28	17	15	0.072	0.068	20	17	0.17	0.18

Here, T_1: Control (no fertilizer and manure), T_2: RFD (Recommendation Fertilizer Dose), T_3: 100% RFD + Pressmud 10 t ha^{-1}, T_4: 75 % RFD + Pressmud 10 t ha^{-1}, T_5: 75 % RFD + Pressmud 10 t ha^{-1} + Poultry litter 5 t ha^{-1}, T_6: 50 % RFD + Pressmud 10 t ha^{-1} + Poultry litter 5 t ha^{-1}, T_6: 50 % RFD + Pressmud 10 t ha^{-1} + Poultry litter 5 t ha^{-1}, T_7: 100 % RFD + Poultry litter 5 t ha^{-1}, T_8: 75% RFD + Pressmud 5 t ha^{-1} + Poultry litter 5 t ha^{-1}.

IV. Conclusion

The overall result of this experiment shows that The overall result revealed that among eight treatments, 100% RFD + Pressmud 10 t ha^{-1} was given highest plant height, stalk height, salk diameter, highest cane yield (94.13 tha^{-1} and 83.33 tha^{-1}) and benefit cost ratio (2.26 and 2.00) in both locations.

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Considering yield and BCR were achieved from 100% recommended organic fertilizer dose plus pressmud 10 tha^{-1} applying in sugarcane cultivation. So, it can be concluded that applying 100% of the recommended organic fertilizer dose plus pressmud ten tha^{-1} for sugarcane cultivation might be recommended at Active Tista Floodplain soils.

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