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Effect of Integrated Nutrient Management on Growth, Yield and Yield Attribute of Sugarcane

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Fertiliser is one of the expensive inputs for sugarcane production in Bangladesh. As a long duration and exhaustive crop, it depletes a considerable amount of nutrients from soil. As a result, soil fertility in sugarcane growing areas is declining. Considering this issue, a field experiment was conducted in the location of Iswardi, Pabna in Bangladesh during 2013-2014 cropping season. In this experiment, seven treatments were used to appraise their effects on growth, yield and yield attribute of sugarcane. All these treatments were completely randomised and replicated thrice. Among the treatments, the highest growth parameters such as internodes length (17.20 cm), number of internodes (22.67), plant height (4.38 m), stalk height (2.86 m) and stalk girth (23.62 mm) were achieved in treatment with combined application of poultry litter and inorganic fertiliser (Treatment 3).Maximum tiller population (211.76 x 10^3) was also found with this treatment at 150 days after transplanting (DAT).Tiller population increased from 120 to 150 DAT and after that time, decreased gradually. The highest millable cane stalks (126.15 x 10^3/ha) and cane yield (144.02 t/ha) were also recorded in the same treatment and followed by the treatment with cow dung and inorganic fertiliser (Treatment 4). Maximum amount of chlorophyll (40.46 spad unit), LAI (7.57) and dry matter (3.81 kg/m^2) were also obtained from the treatment with poultry litter (Treatment 3) followed by the treatment with cow dung (Treatment 4). As for the economic aspect of fertiliser management packages, maximum benefit cost ratio (BCR) of 4.06 was obtained from the treatment with poultry litter followed by treatment with cow dung. Significant changes were not found in one cycle of sugarcane cultivation in initial and postharvest soil characteristics viz., *pH, organic C, total N, P, K and S contents due to integrated use of different fertiliser packages. It is concluded from the present findings that treatment with combined application of poultry litter followed by the treatment with cow dung and inorganic fertiliser exhibited better productivity, profit and integrated nutrient management technology for sole sugarcane cultivation without soil fertility degradation in High Ganges River Floodplain soils.*

Keywords: *Nutrient, fertiliser, growth, yield, sugarcane.*

Sugarcane is the only sugar yielding and economically important crop in Bangladesh. It provides a rich source of sucrose, alcohol and organic matter waste which is utilised as fertiliser. About 70 per cent of the world's total sugar is produced from sugarcane (Hossain & Abdulla, 2015). Sugarcane occupies a pivotal position in the agricultural economy of

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Bangladesh. In Bangladesh, on an average of 4.5 million tonnes of sugarcane is produced annually from 0.11 million hectares of land. It occupies on an average, 1.39 per cent of the country's total cultivable land (BER, 2015). Sugarcane is a long duration crop, which occupies the land for 10-14 months from planting to harvesting. Presently average cane yield in Bangladesh is around 50 tonnes per hectare, which is quite low in comparison with many other sugarcane growing countries. The use of chemical fertilisers does not necessarily lead to better farming than the use of organic fertilisers in agriculture. Due to continuous application of only chemical fertilisers and plant protection chemicals in agriculture, soils have been badly degraded. It has destroyed stable traditional ecosystem of the soil (Palaniappan &Annadurai, 1999). There is a need to encourage more productive, cost efficient and eco-friendly farming system (Bhattacharya & Gehlot, 2003).

The concept of integrated soil and nutrient management implies practices such as appropriate crop rotations, cover crops, use of manure, crop residues and fertilisers, conservation and no-tillage, and moisture management etc. (Gopalasundaram *et al.*, 2012). Integrated nutrient management (INM) approach improves and sustains soil fertility and provides a sound basis for crop production systems to meet the changing needs through optimisation of the benefits from all possible sources of plant nutrients in an integrated manner (FAO, 2011). The plant nutrient is very essential for growth and development of crop and it must be applied in required quantity, right time and right place to improve growth and yield of the crop (Senthilnathan & Stalin, 2016). The use of organic fertiliser is a requirement for improving the sustainable productivity of soil. Dutta *et al.* (2003) stated that the use of organic fertilisers together with chemical fertilisers, compared to the use of organic fertilisers alone, had a higher positive effect on microbial biomass and hence soil health. However, the application of organic fertiliser in combination with chemical fertiliser has been reported to increase absorption of N, P and K in sugarcane leaf tissues in plant and ratoon crop, as compared to chemical fertiliser alone (Bokhtiar & Sakurai, 2005). The application of organic matter from such resources as animal manure, crop residues and green manuring has been shown to replenish soil organic C and improve soil fertility (Srivastava *et al.*, 2009). Considering the above facts, a study was conducted with objectives as below:

i) to study the effect of organic and chemical fertilisers with their combinations on growth, yield and yield attributes of sugarcane,
ii) to observe the influence of organic and chemical fertilisers on the nutrient status of initial and postharvest soils, and
iii) to find out the economics of different nutrient management practices.

MATERIALS AND METHODS

Experimental site, treatments and design

The field experiment was carried out at the Physiology and Sugar Chemistry Division, Soil Science and Nutrition Division and Farm Division in Bangladesh Sugarcrop Research Institute (BSRI), Ishwardi, Pabna, Bangladesh (24°06'56.6"N 89°05'17.0"E) during 2013-2014. The soil of the experimental site is calcareous alluvial soil with low organic carbon (0.72%). The soil type of the site is silty loam. Seven treatment combinations, as given below, of the experiment were tested (*Table 1*).

T_1 - Control,
T_2 - 165:55:120:30:10:2.5:4 kg N,P, K,S, Mg,Zn,B per hectare,
T_3 - Poultry litter at 5 tonnes per hectare + 95:51: 87: 9:10:2.5:4 kg N, P, K, S, Mg, Zn, B per hectare
T_4 - Cow dung at 15 tonnes per hectare + 36:52:60:17: 10:2.5:4 kg N, P, K, S, Mg, Zn, B per hectare
T_5 - Press mud at 15 tonnes per hectare + 10:50: 43:0:10:2.5:4 kg N, P, K, S, Mg, Zn, B per hectare,
T_6 - Mustard oil cake at 0.5 tonnes per hectare + 140:54:115:25:10:2.5:4 kg N, P, K, S, Mg, Zn, B per hectare, and
T_7 - Green manure at 5 tonnes per hectare + 140:53:100:28:10:2.5:4 kg N, P, K,S, Mg, Zn, B per hectare.

The experiment was laid out in a randomised complete block design (RCBD) and replicated three times. Each plot unit of 48 m^2 in area (8 m x 6 m) was laid out as per experimental treatments and design. All treatments of the experiment were completely randomised and replicated thrice. Polybag settlings were planted following spaced transplanting (STP) method. The settlings raised in polybags were transplanted in the trenches at a distance of 45 cm. In this experiment, the rates of chemical fertilisers for different treatments were calculated on the basis of recommended fertiliser dose (RFD) for high yield goal (HYG) and integrated plant nutrition system (IPNS) based on the composition of each organic waste material and its major nutrient contents. Chemical fertilisers were applied at rates of 165 kg N, 55 kg P, 120 kg K, 30 kg S, 10 kg Mg, 2.5 kg Zn and 4 kg B per hectare in the form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, magnesium sulphate, zinc sulphate and borax, respectively as recommended dose of sugarcane crop. Cow dung, poultry litter, press mud, mustard oil cake and green manure (dhaincha) were applied as per the experimental treatments. All the organic sources and full dose of P, S, Mg, Zn and B fertilisers were applied in trenches and mixed

TABLE 1
TREATMENT DETAILS INCLUDED IN THE EXPERIMENT

No	*Treatment abbreviation*	*Treatment description**
1	T_1	Control
2	T_2	165:55:120:30:10:2.5:4 kg N,P,K,S,Mg,Zn,B/ha
3	T_3	PL @ 5 t/ha + 95:51:87:9:10:2.5:4 kg N,P,K,S,Mg,Zn,B/ha
4	T_4	CD @ 15 t/ha + 36:52:60:17:10:2.5:4 kg N,P,K,S,Mg,Zn,B/ha
5	T_5	PM @ 15 t/ha + 10:50:43:0:10:2.5:4 kg N,P,K,S,Mg,Zn,B/ha
6	T_6	MOC @ 0.5 t/ha + 140:54:115:25:10:2.5:4 kg N,P,K,S,Mg,Zn,B/ha
7	T_7	GM @ 5 t/ha + 140:53:100:28:10:2.5:4 kg N,P,K,S,Mg,Zn,B/ha

**Notes:*
PL – Poultry litter (moisture – 22 %, pH – 7.1, organic carbon – 29.2 %, N – 1.69 %, P – 0.08 %, K – 0.8 %,S – 0.51 %); CD – Cow dung (moisture – 33 %, pH – 8.2, organic carbon – 17.0 %, N – 1.17 %, P – 0.03 %, K – 0.55 %, S – 0.12 %); PM – Press mud (moisture – 51 %, pH – 7.27, organic carbon – 12 %, N – 1.3 %, P – 0.04 %, K – 0.64 %, S – 0.32 %); MOC – Mustard oil cake (moisture – 3 %, pH – 7.21, organic carbon – 30.6 %, N – 5.1 %, P – 0.05 %, K – 1.0 %, S – 0.88 %); GM – Green manure (moisture – 81 %, organic carbon – 41.3 %, N – 2.5 %, P – 0.16 %, K – 1.9 %, S – 0.14 %). In addition varying amounts of inorganic fertilisers as shown was included in the different treatments.

with soil prior to transplanting of settlings. The basal dose of N fertiliser (one third) was applied as side dressing at 30 days after transplanting (DAT). The remaining amounts of N and K fertilisers were applied as top dressing in two equal applications at 120 and 180 DAT. After each application, fertilisers were incorporated into the soil by spade. In the case of green manuring treatments, seeds of dhaincha (*Sesbania aculeata*) were sown in between two rows of sugarcane at the rate of 25 kg per hectare in the month of April. At, 45 days after sowing, dhaincha was cut into small pieces and mixed into the soil by spade. Irrigation was applied in trenches just after transplanting of the settlings in the plots under spaced transplanting method to ensure quick and maximum establishment. Also supplementary irrigation was applied after 15, 60, 90 and 120 DAT when the moisture reached to 60 per cent of the field capacity and 80 per cent of water holding capacity. The soil in the trenches was loosened twice at 30 and 60 DAT to prevent the settlings from suffering from soil compaction. All the plots were kept weed free up to 140 DAT, as the period is considered to be the critical period for crop-weed competition in sugarcane field. The cultural, mechanical and chemical control measures were carried out for insect pests and disease management as and when required. Earthing-up was done three times at 120, 150 and 180 DAT. This operation was converting the ridges into furrow and furrow into ridges. Tying was done twice, first in July and then September to keep the clump straight to protect the cane stalks from lodging against the possibility of strong wind. The dried leaves were removed from plants and green leaves on plants were tied together by taking all the canes in one bundle. Cross tying was done by binding two clumps of adjacent rows together. With regards to the planting date and method, the crop was harvested manually at its physiological maturity stage.

Data collection

Agronomic observations

Tiller population

Number of tiller populations was estimated at 120, 150, 180 and 210 DAT by counting total number of shoots from each plot expressed as thousand per hectare.

Number of millable cane

Number of millable cane stalks was recorded at the time of harvest. Well matured canes fit for milling were counted from net plot area expressed as thousands per hectare.

Plant height

Twenty randomly selected sugarcane stalks from each plot were tagged. Shoot length between soil surface and growing point of shoot was measured at harvest time and the value was expressed in metre.

Cane stalk height

Cane stalk height was measured from 20 randomly selected cane stalks of each plot at harvest time. Stalks were cut at the ground level and the top was removed at the sixth leaf joint from the spindle leaf to measure the actual height and value was expressed in metre.

Cane stalk diameter

Cane stalk diameter was determined at the time of harvest from the same 20 randomly selected cane stalks of each plot. The mean value of top, middle and bottom diameter was considered as the actual diameter of the cane stalk and the value was expressed in millimetre.

Number of internodes per stalk

Total number of internodes of a stalk was determined by counting from 20 randomly selected stalks and thereafter, their average was taken.

Unit stalk weight

Weight of single millable cane stalk was calculated by the ratio of cane yield to number of millable cane per unit area.

Cane yield

The yield of sugarcane stalks was determined and recorded at harvest time from the whole area of each plot. The weight of clean cane stalks was taken for yield data. The yield data of sugarcane stalk was expressed in tonnes per hectare.

Physiological observations

Dry matter production

Dry matter (DM) production was estimated from a sample of five canes selected at random from the net plot area at 240 DAT following destructive harvesting. The collected samples including the leaf, sheath and stalk were cut into small pieces and oven dried at 80°C for seven days up to constant weight. Total dry weights of leaf, sheath and stem were computed to hectare basis based on total plant population per hectare at the time of respective growth stages to obtain the production of dry matter (kg/ha).

Leaf area index

Leaf area was measured by leaf product method i.e., maximum length x maximum width x K where K is equal to 0.75. Leaf area of five cane samples was selected from the net plot area at 240 DAT computed to hectare basis on plant population at the respective growth stages. The values of leaf area index (LAI) were calculated by the ratio leaf area to land area.

SPAD chlorophyll reading

SPAD chlorophyll meter was utilised for taking chlorophyll readings at various stages of crop growth, which were directly correlated to the overall crop condition. The second, third and fourth leaves were selected randomly in the net plot for this purpose. Lower, middle and upper leaf surfaces within the leaf were selected for recording the chlorophyll readings.

Nutrient contents of sugarcane leaf

Total-N content of plant sample was determined by semi-micro kjeldahl method (Page *et al.*, 1982; Tandon, 2013).The content of P in the plant extract was determined colorimetrically by developing blue colour with stannous chloride ($SnCl_2 \cdot 2H_2O$) reduction of phosphomolybdate blue colour complex to measure using UV-VIS spectrophotometer at 660 nm wavelength (Jackson, 1973). Potassium content of the plant extract was determined with the help of a flame photometer using 768 nm wavelength (Gupta *et al.*, 2012). Sulphur content was determined turbidimetrically from plant extract with the help of UV-VIS spectrophotometer using barium chloride ($BaCl_2.2H_2O$) as a turbidimetric agent (Tandon, 2013).

Nutrient contents of soil and organic source

Soil water suspension being maintained at 1:2.5 ratio was prepared for determination of soil pH using pH meter (Gupta, 2013).Soil organic carbon content was determined by wet oxidation method. Organic matter content was calculated by multiplying organic carbon (%) with the Van Bemmelen factor 1.724 (Gupta *et al.,* 2012). Total N content of soil was determined by micro-Kjeldhal method (Page *et al.,*1982). Soil sample was extracted with 0.05M $NaHCO_3$ at pH=8.5 and available P content in soil extract was determined by spectrophotometric method (Sparks *et al.*, 1996). Soil sample was extracted with 1N NH_4OAc at pH=7.0 and exchangeable K content in soil extract was analysed by flame photometric method (Gupta *et al.*, 2012). Soil sample was also extracted with 0.15 per cent $CaCl_2$ and available S content in soil extract was determined by turbidimetric method (Tandon, 2013).

Economic analysis

Total production cost was calculated as the sum of all variable costs. The variable costs were used in the analysis were the costs of land preparation, prices of all variable inputs including seed cane, fertilisers, pesticides, irrigation, etc. and labour cost at current rates. These costs were considered based on the information provided by local farmers and local market prices of Ishwardi, Pabna. Gross return, gross margin and benefit cost ratio (BCR) were calculated to determine the economic suitability of the experimental treatments. For calculating gross return, gross margin and BCR, the market price of cane at the time of harvest was considered. Prices of inputs and outputs were determined in Bangladeshi Taka (BDT) based on prices in the local (Ishwardi, Pabna) market in 2019. For better comparisons, all the economics data (cost of production, gross return and net returns) were converted from BDT to US$ using an exchange rate of 1US$ = 84.8 BDT (according to the currency conversion rate on 12 December, 2019). Gross margin was calculated as the difference between gross return and total variable cost for each treatment. Net return was calculated as the difference between gross return and total cost for each treatment. The BCR for each treatment was calculated from the gross return divided by the total cost.

Statistical analysis

The experimental data were statistically analysed by ANOVA using "Statistix 10" computer based software to assess the differences between treatments, and the means were separated using least significant difference (LSD) at the 5 per cent level of significance ($p < 0.05$) (Gomez & Gomez, 1984).

RESULTS AND DISCUSSION

Growth rate

The growth rate varied from 1.48 cm to

TABLE 2
EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH RATE OF SUGARCANE

*Treatment**	*Growth rate (cm /d) at different days after stem formation (DASF)*		
	30	*60*	*90*
T_1	1.48 d	1.77 e	1.56 b
T_2	1.61 c	1.92 d	1.61 b
T_3	1.65 ab	2.08 a	1.74 a
T_4	1.64 ab	2.01 b	1.74 a
T_5	1.61 c	1.94 d	1.70 a
T_6	1.66 a	2.00 bc	1.72 a
T_7	1.63 bc	1.95 cd	1.75 a
LSD at 0.05	0.030	0.054	0.052

*For treatment details see *Table 1*
Figure(s) having common letter(s) in a column did not differ significantly at 5 per cent level significance by DMRT.

1.66 cm per day at 30 days after stem formation (DASF) as shown in *Table 2*. The maximum growth rate (1.66 cm/d) was found in treatment T_6 and it was statistically significant to other treatments. Similarly, the lowest growth rate in those DASF was recorded from control. On the other hand, the data on growth rate at 60 DASF, the highest growth rate (2.08 cm/d) was recorded in treatment T_3 among all the treatments, although all the treatments were found to be significantly different. While control treatment showed the lowest growth rate (1.48 cm/d), treatment T_7 recorded the highest growth rate (1.75 cm/d) among all the treatments. Furthermore, the lowest growth rate (1.56 cm/d) was observed in the control treatment. Growth rate determines the productivity of the sugarcane crop. But growth rate in sugarcane is influenced by many factors *viz.*, variety, soil moisture, time of planting, spacing, soil nutrient supply, soil tilth and aeration, temperature and other cultivation practices observed by several workers (Babu *et al.*, 2007; Darandale, 2015). The study indicated that treatments receiving both organic and chemical fertilisers increased growth rate over control. The increased growth rate might be due to the better utilisation of chemical nutrients in combination with organic sources than chemical source alone. These findings were also in agreement with the results shown by Bokhtiar and Sakurai (2007) and Sharma *et al.* (2009).

Tiller population

Data on tiller population indicated that the highest tiller population (197.17 x 10^3/ha) was obtained from treatment T_3 at 150 DAT and the lowest tiller population (96.39 x 10^3per hectare) was found from the control treatment at 210 DAT (*Table 3*). Tiller population increased from 120 to 150 DAT and after that time, it decreased gradually. Significant difference on tiller population was noticed among the experimental treatments. The productivity of sugarcane crop is largely enhanced by tiller production. Babu *et al.* (2007) and Darandale (2015) observed that many factors *viz.*, variety, soil moisture, planting time, spacing, soil nutrient supply, soil tilth and aeration, temperature and other cultivation practices influenced sugarcane tillering. The

TABLE 3
EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON TILLER POPULATION OF SUGARCANE

*Treatment**	*Tiller population (x 10^3/ha) at different days after transplanting (DAT)*			
	120	*150*	*180*	*210*
T_1	102.43 e	151.36 d	136.26 d	96.39 d
T_2	109.78 de	163.36 cd	147.45 cd	107.53 cd
T_3	156.98 ab	197.17 ab	192.87 a	145.13 a
T_4	146.49 abc	190.33 abc	181.45 ab	138.49 ab
T_5	121.52 cde	171.12 bcd	157.15 bcd	116.54 bcd
T_6	167.60 a	211.76 a	172.49 abc	128.51 abc
T_7	134.06 bcd	181.51 bc	164.72 bc	122.31 bc
LSD at 0.05	25.19	29.13	26.94	22.66

* For treatment details see *Table 1*
Figure(s) having common letter(s) in a column did not differ significantly at 5 per cent level significance by DMRT.

increased tiller might be due to the better utilisation of chemical nutrients in combination with organic sources than chemical source alone. These findings were also in agreement with the results of Sharma *et al.* (2003); Jeyaraman and Alagudurai (2003); Bokhtiar and Sakurai (2007) and Umesh *et al.* (2007). In this study, tiller mortality rate was less because timely irrigation was done to maintain adequate soil moisture along with organic and chemical fertilisers and ideal spacing with high interception of light for maximum duration during growing period.

Yield contributing parameters

In the experiment, the highest growth parameters such as internodes length (17.20 cm), number of internodes (22.67), plant height (4.38 m), stalk height (2.86 m) and stalk girth (23.62 mm) were observed in T_7, T_3, T_4, and T_5; all with varying amounts of inorganic fertilisers added (*Table 1*), respectively (*Table 4*). The lowest values of internodes length (14.33 cm), number of internodes (19.33), plant height (3.85 m), stalk height (2.43 m) and stalk girth (20.14 mm) were found in the control treatment. The results of these parameters were recorded maximum where the crop received both organic and chemical fertilisers. These findings are in agreement with the results of Sonawane and Sable (2000) and Kanjana *et al.* (2007). Treatment T_3 produced significantly the highest numbers of millable canes (126.15x10^3/ha), unit cane weight (1.14 kg) and cane yield (144.02 t/ha) among all the treatments (*Figures 1 & 2*). The control treatment produced the lowest numbers of millable canes (72.25x10^3/ha), unit cane weight (0.76 kg) and cane yield (54.88 t/ha). The higher number of millable canes was found in the organic fertiliser treated plot that attributed to less tiller mortality due to the higher nutrient uptake. Significant effect of different fertiliser managements on the yield of sugarcane was mainly associated with cane height, cane diameter and unit stalk weight. From the result, it was revealed that if poultry litter was applied at the rate of 5 tonnes per hectare and IPNS of N, P, K and S chemical fertilisers, the response on cane yield was statistically at par. This indicates that chemical fertiliser could be saved by the use of organic fertiliser. Similar findings were also reported by Singh *et al.*

TABLE 4
EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD ATTRIBUTES OF SUGARCANE

Treatment	*Internode length (cm)*	*Internode number*	*Plant height (m)*	*Stalk height (m)*	*Stalk girth(mm)*
T_1	14.33 e	19.33 e	3.85 c	2.43 c	20.14 b
T_2	14.43 de	20.33 d	3.91 c	2.52 bc	20.84 b
T_3	16.23 b	22.67 a	4.22 ab	2.86 a	22.82 a
T_4	15.70 c	22.00 b	4.38 a	2.83 a	23.26 a
T_5	14.67 d	21.67 c	3.91 c	2.65 abc	23.62 a
T_6	15.49 c	22.00 b	4.13 abc	2.79 ab	22.64 a
T_7	17.20 a	22.00 b	3.95 bc	2.69 abc	22.68 a
LSD at 0.05	0.252	0.246	0.290	0.310	1.50

* For treatment details see *Table 1*
Figure(s) having common letter(s) in a column did not differ significantly at 5 per cent level significance by DMRT.

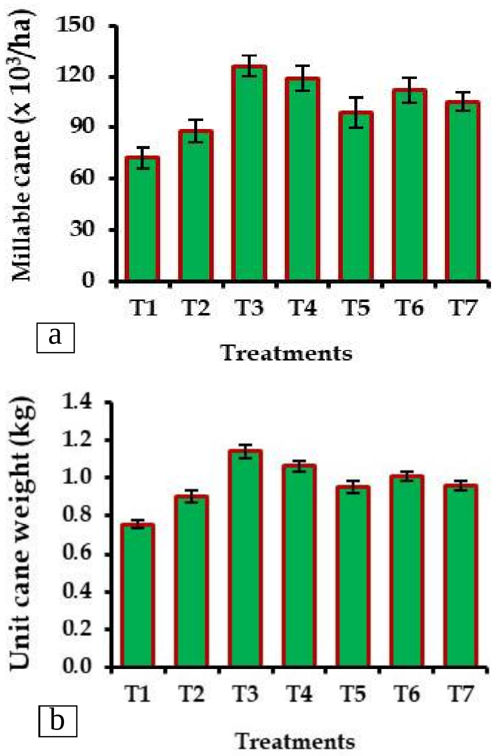

Figure 1 Effect of integrated nutrient management on millable cane (a) and unit cane weight (b) of sugarcane. Note: *Bars indicate the SE (n=3)*

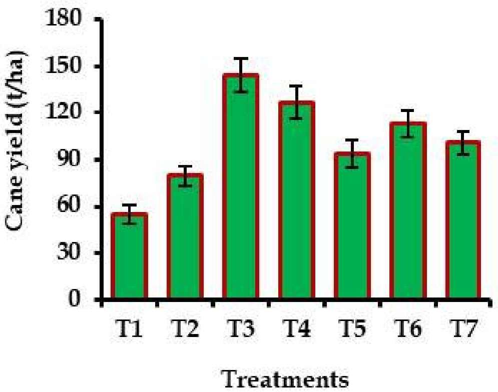

Figure 2 Effect of integrated nutrient management on yield of sugarcane. Note: *Bars indicate the SE (n=3)*

(2007), Srivastava *et al*. (2008) and Senthilnathan and Stalin (2016).

Physiological parameters

The experimental results in (*Table 5)* showed that the application of different nutrient management practices exerted a significant impact on chlorophyll content in cane leaf tissue. Treatment T_3 gave significantly higher chlorophyll (40.46 spad units) but it was statistically similar to T_4, T_5, T_6 and T_7. Significantly lower amount of chlorophyll (33.46 spad unit) was recorded in the control treatment. These findings are in agreement with Bokhtiar and Sakurai (2007) and Roksana (2012). In the case of LAI, T_3 exhibited significantly higher LAI (7.57) than other experimental treatments, but it was statistically identical to T_4. Furthermore, the lowest LAI (4.28) was found in the control treatment. The higher population density exerted LAI and this might be due to the increased number of leaves per unit ground area of organic manure treated plots. The optimum LAI value at higher fertility level received considerable attention for yield increase in sugarcane. The maximum LAI were higher within 120 to 240 DAT due to rapid vegetative growth of sugarcane plant. Similar findings were supported by Roksana (2012) and Senthilnathan and Stalin (2016). Treatment T_3 produced significantly maximum dry matter (3.81 kg/m^2) among all the treatments but it was not significantly different from T_4 and T_6. The control treatment obtained significantly minimum amount of dry matter (2.59 kg/m^2). Due to the rapid vegetative growth of sugarcane plant, the accumulation of maximum dry matter was higher within 120 to 240 DAT. LAI accelerated dry matter production in sugarcane. Integrated use of organic fertiliser along with chemical fertiliser was extremely important for growth parameters and these

TABLE 5
EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON PHYSIOLOGICAL CHARACTERISTICS OF SUGARCANE

*Treatment**	*Chlorophyll(spad unit)*	*Leaf area index*	*Dry matter (kg/m)*
T_1	33.46 b	4.28 f	2.59 d
T_2	33.77 b	5.09 e	3.12 c
T_3	40.46 a	7.57 a	3.81 a
T_4	38.45 ab	6.98 ab	3.63 ab
T_5	34.98 ab	5.51 de	3.03 cd
T_6	37.59 ab	6.38 bc	3.42 abc
T_7	36.83 ab	5.91 cd	3.28 bc
CV (%)	8.68	6.51	8.55
LSD at 0.05	5.63	0.69	0.50

* For treatment details see *Table 1*
Figure(s) having common letter(s) in a column did not differ significantly at 5 per cent level significance by DMRT.

results were agreed with Vanaja and Raju (2002) and Darandale (2015).

Nutrient content of sugarcane leaf

Nutrient contents of sugarcane leaves at 240 DAT were evaluated (*Table 6*). The contents of N, P, K and S in leaf tissues varied significantly as influenced by the combinations of different nutrient applications. Treatment T_3 showed the highest N content (1.34%). The second highest N content (1.25%) was found in T_4 followed by treatment T_6 (1.23%). Treatment T_3 showed the highest P content (0.080%) followed by T_4 (0.078%). The control treatment gave the lowest value of P (0.060%). Treatment T_4 recorded the highest K content (1.25%) and the lowest K content (1.00%) was found from control treatment. Treatment T_5 showed the highest S content (0.22%) followed by T_3 (0.21%). These findings agree with those of Bokhtiar and Sakurai (2005, 2007).

TABLE 6
EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON NUTRIENT CONTENT OF SUGARCANE LEAF TISSUE

*Treatments**	*Total N (%)*	*P (%)*	*K (%)*	*S (%)*
T_1	1.03 e	0.060 e	1.00 e	0.15 e
T_2	1.18 cd	0.064 d	1.13 c	0.18 d
T_3	1.34 a	0.080 a	1.18 b	0.21 ab
T_4	1.25 b	0.078 b	1.25 a	0.20 bc
T_5	1.17 d	0.064 d	1.08 d	0.22 a
T_6	1.23 b	0.076 c	1.15 c	0.19 cd
T_7	1.20 c	0.076 c	1.13 c	0.19 cd
LSD at 0.05	0.021	1.445	0.024	0.014

* For treatment details see *Table 1*
Figure(s) having common letter(s) in a column did not differ significantly at 5 per cent level significance by DMRT.

Nutrient status of initial and postharvest soils

The effects of different integrated nutrient management treatments on nutrient status of post harvest soils have been presented in *Table 7*. The results of this study revealed that soil organic carbon (SOC), total N, available P, available K and available S showed no significant changes in soils of the plots where organic materials were applied with chemical fertilisers in sugarcane compared to control and chemical fertiliser applied plots. This result is similar to that of Nagaraju *et al.* (2000), Zaman *et al.*(2000) and Sharma *et al.* (2009), who opined that the use of organic fertiliser in combination with chemical fertiliser increased soil N and P contents, renewed organic matter and improved physico-chemical properties of soil.

Economic analyses

The economic aspect of any fertiliser management package is important for crop production and acceptance by the farmers. The cost and return analysis helps to decide the suitability of a fertiliser management package. Cost and return analysis was performed considering all the production cost involved in sugarcane. Total production cost of sugarcane was assessed for different treatment combinations (*Table 8*). Total production cost of sugarcane varied from US$765 to US$1 147 per hectare. From the results, it was observed that T_6 had the highest production cost at US$1 147 per hectare. On the other hand, the control had the lowest production cost. All the organic and chemical fertiliser treatment combinations increased gross margin progressively over control. The highest gross margin was observed in T_3 with the values of US$4 238 per hectare and the lowest gross margin of US$1 615 per hectare was recorded in control. In case of net return, T_3 produced the highest net return of US$3 194 per hectare and the lowest net return of US$850 per hectare was noted from the control. Maximum BCR of 4.1 was obtained from T_3 followed by T_4 (BCR=3.5).

TABLE 7
NUTRIENT STATUS OF INITIAL AND POSTHARVEST SOILS AS AFFECTED BY INTEGRATED NUTRIENT MANAGEMENT FOR SUGARCANE PRODUCTION

*Treatments**	*pH*	*SOC (%)*	*N (%)*	*P (mg/kg)*	*K (cmol/kg)*	*S (mg/kg)*
Initial soil	7.55	0.720	0.0600	13.00	0.270	30.00
Postharvest soil						
T_1	7.60	0.715	0.0598	12.94	0.268	29.91
T_2	7.55	0.717	0.0599	12.95	0.268	29.93
T_3	7.50	0.725	0.0600	13.00	0.269	30.00
T_4	7.50	0.723	0.0599	12.95	0.269	29.95
T_5	7.55	0.722	0.0600	12.95	0.268	30.00
T_6	7.55	0.720	0.0599	12.97	0.269	29.97
T_7	7.60	0.722	0.0599	13.00	0.269	29.97
LSD at 0.05	NS	NS	NS	NS	NS	NS

* For treatment details see *Table 1*
Figure(s) having common letter(s) in a column did not differ significantly at 5 per cent level significance by DMRT.

TABLE 8
ECONOMIC ANALYSES OF INTEGRATED NUTRIENT MANAGEMENT FOR SUGARCANE PRODUCTION

*Treatment**	*Total cost*	*Gross return*	*Net return*	*Benefit cost ratio (BCR)*
	(US $ /ha)			
T_1	765	1615	850	2.1
T_2	989	2342	1353	2.4
T_3	1044	4238	3194	4.1
T_4	1077	3732	2655	3.5
T_5	956	2756	1800	2.9
T_6	1147	3323	2175	2.9
T_7	974	2969	1996	3.1

Note: 1 US$ = 84.8 BDT (on December 12, 2019 at https://transferwise.com/tools/exchange-rate-alerts/)
*See *Table 1*
Cost: Cane production cost = US$ 765.07 /ha, Urea = US$ 0.19 /kg, TSP = US$ 0.26 /kg, MoP = US$ 0.18 /kg, Gypsum = US$ 0.14 /kg, Zinc sulphate = US$ 1.65 /kg, Boric acid = US$ 1.41 /kg, Magnesium sulphate = US$ 0.35 /kg, Cow dung = US$ 0.01 /kg, Press mud = US$ 0.006 /kg, Poultry litter = US$ 0.02/kg, Mustard oil cake = US$ 0.35 /kg and Green manure = US$ 0.006 /kg.

CONCLUSION

To obtain more yield from sugarcane, organic fertilisation in combination with chemical fertilisers can be a good agronomic management practice. Considering the present experimental findings, integrated applications of T_3 followed by T_4 proved to be the most effective and profitable combination for improving growth, yield and quality of sugarcane. These treatments showed better productive and profitable integrated nutrient management technology for sole sugarcane cultivation without soil fertility degradation in High Ganges River Floodplain soils.

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