Efficacy of Organic Fertilizers on the Growth, Yield and Quality of Sugarcane

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ABSTRACT

A field experiment was conducted at Physiology and Sugar Chemistry, Soil Science and Nutrition and Farm Divisions of Bangladesh Sugarcrop Research Institute (BSRI), Ishurdi, Pabna during 2012-2013 cropping season. In the experiment, five types of organic fertilizers *viz*., poultry litter (PL), cow dung (CD), mustard oil cake (MOC), green manure (GM) and press mud (PM) at three different levels were used to evaluate their performances on the yield and quality of sugarcane. The experiment was laid out in randomized complete block design (RCBD) and replicated three times. Results showed that cane yields of 131.55, 127.05, 124.50, 118.30, and 114.93 t ha^{-1} were obtained when PL @ 5 t ha^{-1}, CD @ 15 t ha^{-1}, MOC @ 0.5 t ha^{-1}, PM @ 15 t ha^{-1}, and GM @ 5 t ha^{-1} accompanied with equal supplementary dose (50%) of recommended fertilizer (SDRF) were applied respectively. Juice quality parameters *viz*., pol in cane, purity, and phosphate contents were found statistically non-significant difference among all the treatments. Maximum sugar yield (15.93 t ha^{-1}) was obtained when the crop received PL @ 5 t ha^{-1} + 50% SDRF followed by 15.33, 15.20, 14.30, 14.07 t ha^{-1} from CD @ 15 t ha^{-1}, MOC @ 0.5 t ha^{-1}, PM @ 15 t ha^{-1} and GM @ 5 t ha^{-1} with 50% SDRF, respectively. Maximum benefit cost ratio (BCR) value of (3.80) was obtained from T_{15} treatment (PL @ 5 t ha^{-1} + 50% SDRF) as compared to other treatments. The study revealed that the organic fertilizers PL @ 5 t ha^{-1}, CD @ 15 t ha^{-1}, MOC @ 0.5 t ha^{-1}, GM @ 5 t ha^{-1} and PM @ 15 t ha^{-1} along with 50% supplementary doses of recommended fertilizers (SDRF) showed better growth, yield and quality of sugarcane.

Key words: Sugarcane, efficacy, organic fertilizer, growth, yield, quality

INTRODUCTION

Sugarcane in national economy sector shares 0.81% of total GDP. Sugarcane in agricultural sector shares 9.11% of total value of agricultural output and occupies only 1.39% of Bangladesh gross cropped area. Sugarcane, a long duration and large biomass accumulating crop, removes substantial quantities of plant nutrients from soil. In Bangladesh depletion of soil fertility is a major constraint for sustainable crop production. The increasing land use intensity has resulting in a massive exhaustion of nutrients from soil. Mono-cropping practices, use of low and unbalanced doses of

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inorganic fertilizer, nutrient leaching with monsoon rain, nutrient loss through soil erosion and other process also cause depletion of soils. Farmers generally apply chemical fertilizers for sugarcane cultivation due to their easy availability and scarcity of organic manures. As a result, soil productivity has come down and concerns like physical, chemical and biological degradation and declining organic matter content are also becoming increasingly relevant. Excessive and improper use of chemical fertilizers has many undesirable effects on the environment such as water and soil pollution, besides a large part of applied nutrients is lost through the process of fixation, leaching run off and volatilization resulting into low yield of sugarcane. Over the last 30 years, additional nutrients applied as fertilizers have been responsible for 55% yield increase in developing countries (FAO, 1998). Fertilizer is a major input of modern farming since about 50% of the world's crop production depends on this input (Pradhan, 1992). However, neither sustainable higher crop production can be obtained by using inorganic fertilizer alone nor by applying only organic fertilizer (Bair, 1990). In this context, integrated plant nutrient management, the combined use of organic and inorganic nutrients can be a good approach to combat nutrient depletion and promote sustainable crop production.

Dotaniya et al. (2016) reported that application of sugarcane industries by-products, such as press mud reduced the recommended dose of chemical fertilizers and improved soil organic matter during crop production. Press mud is an organic waste of sugarmills and supplies 1.0-1.5% N, 1.09-1.53% P and 0.25-0.66% K. Besides, it is a good source of micronutrient (Kale, 1981). Furthermore, successive applications of green manure help increase the total carbon, total nitrogen, exchangeable K contents, porosity of the soil and decrease its bulk density (Bokhtiar et al., 2003; Goto and Nagata 2000). In sugarcane cropping system, legumes are grown either in sequence or as an intercrop for green manure, grain or fodder. Legumes in sugarcane cropping system benefit in terms of nitrogen nutrition of sugarcane and amelioration of yield decline. Press mud, one of the important organic sources emanating from sugar industry, is a good source of nutrients. Results of long-term experiments conducted for 40 years on the effect of manuring in sugarcane in different cropping systems indicated that yield of unmanured sugarcane decreased considerably in cereal based cropping system and inclusion of legumes like sun hemp and lucerne in cropping system not only sustained the yield of unmanured sugarcane but also improved the productivity of manured sugarcane. On an average, sugarcane crop yielding 100 tons, removes 208, 53 and 280 kg per hectare of N, P2O5 and K2O, respectively from the soil. Hence it is essential to replenish the depleted soil with plant nutrients at desired levels to restore and sustain the fertility/productivity of soils through integrated nutrient management system. Organic sources of nutrients not only help in supplementing the nutrients to sugarcane but also maintain favourable physical, chemical and biological soil environment.

The nutrient management strategies should be in tune with large nutritional requirements ensuring full replenishment of the nutrients depleted through intensive sugarcane-based production systems. The management of plant nutrients for high sugarcane production with improved quality traits demands integration of chemical fertilizers with organics such as green manures, crop residues, bio-manures and sugar factory by-products to enhance nutrient use efficiency and reduce production cost. Use of organics in association with chemical fertilizers has increased the nutrient use efficiency and help in correcting the emerging deficiencies of nutrients other than N, P, K and particularly micronutrients. Therefore, to improve the productivity per unit area and time without compromising on soil health, it is inevitable to formulate an integrated approach involving all the means and ways *viz.*, cultural, use of organic and inorganic, crop residue recycling and bio-fertilizers (Shukla *et al.*, 2013). Sugarcane yield increased with integration of organic and inorganic fertilizers and it showed long-term sustainability in sugarcane based system (Shukla *et al.,* 2015). Though Integrated Nutrient Management (INM) has been considered a broad based remedy against soil fertility decline, the management practices advocated by scientists, however, have been lot more ignored by the farmers when compared to control of insect pests and diseases. In an extension perspective, such differences in perception between the users of the soil and the experts are generally common. Nevertheless, in the present study, it was observed that adoption of integrated nutrient management practices resulted in reduction of total fertilizer cost with increased productivity and thereby additional income to the practicing farmers. Though nutrient management is an issue of concern for cane growers as the crop puts a heavy demand on soil resources, adoption of INM practices is still a reservation and the present study attempts to gain insights into this fast spreading technology. The present experiment was undertaken to evaluate the efficacy of organic fertilizers and their doses on growth, yield and quality of sugarcane.

MATERIALS AND METHODS

The field experiment was carried out at all the three divisions of Physiology and Sugar Chemistry, Soil Science and Nutrition and Farm in Bangladesh Sugarcrop Research Institute (BSRI), Ishurdi, Pabna during 2012-2013 cropping season. The Institute is situated between 24°8′ north latitude and 89°4′ east longitude. The experimental site represents the High Ganges River Flood Plain soils under the AEZ 11. The experimental site belongs to Sara soil series of calcareous soil type under High Ganges River Flood Plain. That experimental field was a medium high land soil at well drained condition. The experiment was laid out in randomized complete block design (RCBD) and replicated three times. The unit plot size was 8 m 6 m. Sixteen (16) treatment combinations were taken in this experiment. In this experiment, three different doses of five organic fertilizers *viz*., poultry litter (PL), cow dung (CD), mustard oil cake (MOC), green manure (GM) and press mud (PM) plus 50% supplementary doses of recommended fertilizer (SDRF) as per fertilizer recommendation guide (FRG, 2012) for high yield goal (HYG) were applied. The experimental treatments were: T_1 = Control (native soil), T_2 = GM @ 5 t ha^{-1} + 50 % recommended fertilizer (SDRF), T_3 = GM @ 10 t ha^{-1} + SDRF, T_4 = GM @ 15 t ha^{-1} + SDRF, T_5 = PM @ 5 t ha^{-1} + SDRF, T_6 = PM @ 10 t ha^{-1} + SDRF, T_7 = PM @ 15 t ha^{-1} + SDRF, T_8 = CD @ 10 t ha^{-1} + SDRF, T_9 = CD @ 15 t ha^{-1} + SDRF, T_{10} = CD @ 20 t ha^{-1} + SDRF, T_{11} = MOC @ 0.25 t ha^{-1} + SDRF, T_{12} = MOC @ 0.5 t ha^{-1} + SDRF, T_{13} = MOC @ 1 t ha^{-1} + SDRF, T_{14} = PL @ 3 t ha^{-1} + SDRF, T_{15} = PL @ 5 t ha^{-1} + SDRF and T_{16} = PL @ 10 t ha^{-1} + SDRF.

As a test crop, Isd 39 was chosen for the recently released high sugar content variety. Sugarcane settlings raised in poly bag for transplanting in the field. For raising polybag settlings, single budded setts were made in such a way that at least 1.5 cm stalk was kept above the node containing one viable eye bud and about 3.0 cm was kept below the node. All of the single budded setts were treated with Bavistin solution (1:1000) for 30 minutes as a preventive measure against fungal infection (Talukder *et al*, 2005). The land was prepared by using tractor plough and harrow. On achieving the desired tilth and uniform leveling 20 cm deep trenches were made maintaining row distances of 1.0 m by tractor trencher. The plot was laid out as per treatments and design of the experiment. Following spaced transplanting (STP) method, poly bag settlings were transplanted in 01.11.2012. The settlings raised in poly bag were transplanted in the trenches at a distance of 45 cm.

In this experiment, 50% doses of N, P, K and S and full doses of Mg, Zn and B were applied at 85, 30, 60, 15, 10, 2.5 and 2 kg ha^{-1}, respectively. Nitrogen and phosphorus were applied in the form of urea and triple superphosphate (TSP) while potash was applied as muriate of potash (MoP). Sulphur, magnesium, zinc and boron were applied in the form of gypsum, magnesium sulphate, zinc sulphate and boric acid. Cow dung, poultry litter, press mud, mustard oil cake and green manure (*Crotalaria juncea*) were applied as organic fertilizers. All the organic sources and full of triple superphosphate, gypsum, magnesium sulphate, zinc sulphate, boric acid and 1/3rd of muriate of potash were applied in trenches and mixed thoroughly with soil prior to transplanting of settlings. The basal dose of urea (1/3rd) was applied as side dressing at 30 days after transplanting (DAT). The rest amount of urea and muriate of potash were applied as top dressing in two equal splits at 120 and 180 days after transplanting (DAT).

After each application, fertilizers were incorporated into the soil by spade. For the management of green manure treatments, seeds of green manure crop at 25 kg ha^{-1} were sown in between cane rows after 120 days of transplanting of sugarcane during mid April. After 45 days, this green manure (GM) crop was ploughed down in *situ* with soil and thereafter, irrigation was applied for decomposition of green manure plants.

Irrigation was applied in trenches just after transplanting of the settlings in the plots to ensure maximum establishment. Also supplementary irrigation was applied at 15, 60, 90 and 120 DAT when the moisture reached to 60% depletion of the field capacity. The soil in the trenches was loosened twice at 30 and 60 DAT to prevent the settlings suffering from soil compaction. All the plots were kept weed free up to 140 days after transplanting, as the period was considered to be the critical period for crop-weed competition in sugarcane field. Pest and disease management were done following the cultural and chemical practices as recommended by Bangladesh Sugarcrop Research Institute. Prior to transplanting Regent 3G was applied @ 33 kg ha^{-1} in the trenches to control termite. To prevent borers, Furadan 5G was applied @ 32 kg ha^{-1} in two times (90 and 150 DAT). Earthing-up was done three times on 120, 150 and 180 DAT. This operation converted the ridges into furrow and furrow into ridges. Tying was done in two times, first in July and then September to keep the clump straight to protect the cane stalks from lodging. The dried leaves were removed from the plants and older 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.

The crop was harvested manually at its full maturity stage after 12 months. Twenty (20) sugarcane stalks were randomly harvested from each plot to determine growth, yield and yield attributes parameters. Data regarding tiller population, number of millable cane, plant height, cane stalk height, cane stalk diameter, unit stalk weight, cane yield and cane quality parameters such as pol in cane, purity, sugar recovery were recorded at the time of harvest. The number of tiller populations was estimated at the time of 120, 150, 180 and 210 DAT by counting the total number of shoots from each plot. Number of millable cane stalks per plot was recorded at harvest. Plant height, cane stalk height, cane stalk diameter and number of internodes per stalk were measured from 20 randomly selected cane stalks of each plot at harvest. Weight of single millable cane stalk was calculated through using the following formula:

$$\text{Unit stalk weight (kg)} = \frac{\text{Yield of cane per unit area}}{\text{Number of millable cane from the same unit area}}$$

Yield of sugarcane was recorded at harvest from the whole area of each plot. Juice samples were extracted from ten (10) canes selected at random from the net plot area at harvest. Juice was chemically analyzed for cane quality parameters such as pol in cane and others. Pol readings of the filtered juice samples were recorded with the help of ATAGO 300 digital polarimeter (Anon, 1970). Lane and Eynon (original) method was used to determine reducing sugars and phosphate content of juice was determined by ammonium molybdate method (Varma, 1988).

Pol in cane was computed by the following formulae:

$$\text{Pol \% cane} = \text{Pol \% juice} \quad \frac{100 - (F + 5)}{100} \qquad \text{where, F = Fibre (\%)}$$

Reducing sugars of juice was calculated as per the following formulae:

$$\text{Reducing sugars (\%)} = \frac{FF}{TV} \quad \frac{100}{1000} \quad DF$$

Phosphate content of juice was calculated as per the following formulae:

$$\text{Phosphate (\%)} = \frac{0.05 \quad \text{Abs of sample}}{0.25 \quad \text{Abs of standard solution}} \quad 100$$

Purity of juice was calculated as per the following formulae:

$$\text{Purity (\%)} = \frac{\text{Pol in juice (\%)}}{\text{Brix (\%)}} \quad 100$$

Sugar yield was calculated as per the following formulae:

$$\text{Sugar yield (t ha}^{-1}\text{)} = \frac{\text{Recoverable sucrose} \quad \text{Cane yield (t ha}^{-1}\text{)}}{100}$$

Generated data were compiled and analyzed properly using statistica 10 software. Treatment means were judged with LSD at 5% level of probability.

RESULTS AND DISCUSSION

Growth, yield and yield attribute characters

Tillering at 120 days after transplanting

Evaluating the results reported in Table 1, it was found that the treatment T_{16} with PL @ 10 t ha^{-1} + 50% recommended fertilizer (SDRF) produced significantly higher numbers of tillers (144.73 10^3) per hectare among all the treatments at 120 DAT but it was statistically similar to T_4, T_7, T_9, T_{10}, T_{12}, T_{13}, T_{14} and T_{15} treatments. On the other hand, the treatment T_1 (control) produced significantly lower numbers of tillers (94.63 10^3) per hectare. Furthermore, the treatments T_{15} (PL @ 10 t ha^{-1} + 50 % SDRF) and T_{10} (CD @ 20 t ha^{-1} + 50 % SDRF) produced the second (141.37 10^3) and third (137.90 10^3) highest numbers of tillers per hectare, respectively.

Tillering at 150 days after transplanting

The results in Table 1 indicated that the treatment T_{15} with PL at 5 t ha^{-1}+ 50 % SDRF) produced significantly the maximum numbers of tillers (159.57 10^3) per hectare among all the treatments at 150 DAT, but it was statistically similar to the treatments T_4, T_7, T_9, T_{10}, T_{12}, T_{13}, T_{14} and T_{16}. While the treatment T_1 (control) produced significantly the minimum numbers of tillers (109.23 10^3) per hectare. Furthermore, the treatments T_{10} (CD @ 20 t ha^{-1} + 50% SDRF) and T_{16} (PL @ 10 t ha^{-1}+ 50% SDRF) produced the second and third highest numbers of tillers (153.03 10^3 and 151.03 10^3) per hectare, respectively.

Tillering at 180 days after transplanting

Data on tiller population at 180 days varied significantly due to different experimental treatments as shown in Table 1. The treatment T_{15} with PL @ 5 t ha^{-1} + 50% SDRF) produced significantly higher numbers of tillers (132.50 10^3) per hectare among all the treatments at 180 DAT but it was statistically non-significant with the treatment T_2, T_7, T_9, T_{10}, T_{12}, T_{13}, T_{14} and T_{16} treatments. While the treatment T_1 (control) produced significantly lower numbers of tillers (79.97 10^3) per hectare. Furthermore, the treatment T_{16} (PL @ 10 t ha^{-1} + 50% SDRF) produced second highest numbers of tillers (129.73 10^3) per hectare.

Table 1. Integrated of organic and inorganic fertilizers at different levels on tiller production in sugarcane

Treatments	Tiller population (□ 10^3 ha^{-1})			
	120 DAP	**150 DAP**	**180 DAP**	**210 DAP**
T_1	94.63 e	109.23 e	79.97 f	64.60 e
T_2	117.07 d	132.63 cd	119.90 abcd	108.23 abc
T_3	122.30 cd	139.13 bcd	101.60 e	89.77 d
T_4	133.80 abcd	146.03 abcd	109.83 cde	100.50 bcd
T_5	118.47 d	131.37 d	104.00 e	94.00 cd
T_6	125.23 bcd	136.30 bcd	113.40 bcde	100.77 bcd
T_7	133.73 abcd	145.77 abcd	120.60 abc	109.43 ab
T_8	121.57 cd	137.87 bcd	104.17 de	92.83 d
T_9	134.10 abcd	148.80 abcd	124.97 abc	114.63 ab
T_{10}	137.90 abc	153.03 ab	121.43 abc	109.10 ab
T_{11}	116.60 d	139.13 bcd	103.73 e	93.60 d
T_{12}	133.87 abcd	142.03 abcd	122.87 abc	111.20 ab
T_{13}	134.53 abcd	150.40 abc	123.37 abc	111.17 ab
T_{14}	137.27 abc	147.83 abcd	127.30 ab	115.67a
T_{15}	141.37 ab	159.57 a	132.50 a	122.07 a
T_{16}	144.73 a	151.03 ab	129.73 a	119.40 a
CV (%)	8.41	7.69	8.22	8.31
LSD (P = 0.05)	17.94	18.21	15.76	14.35

Legend:

T_1 = Control; T_2 = GM @ 5 t ha^{-1} + 50% SDRF ; T_3 = GM @ 10 t ha^{-1} + 50% SDRF ; T_4 = GM @ 15 t ha^{-1} + 50% SDRF ; T_5 = PM @ 5 t ha^{-1} + 50% SDRF ; T_6 = PM @ 10 t ha^{-1} + 50% SDRF; T_7 = PM @ 15 t ha^{-1} + 50 % SDRF; T_8 = CD @ 10 t ha^{-1} + 50% SDRF ; T_9 = CD @ 15 t ha^{-1} + 50% SDRF ; T_{10} = CD @ 20 t ha^{-1} + 50% SDRF ; T_{11} = MOC @ 0.25 kg ha^{-1} + 50% SDRF ; T_{12} = MOC @ 0.5 kg ha^{-1} + 50% SDRF; T_{13} = MOC @ 1 kg ha^{-1} + 50% SDRF ; T_{14} = PL @ 3 t ha^{-1} + 50% SDRF ; T_{15} = PL @ 5 ha^{-1} + 50% SDRF and T_{16} = PL @ 10 t ha^{-1} + 50% SDRF .

GM = Green Manure; PM = Press Mud; CD = Cow Dung; MOC = Mustard Oil Cake; PL = Poultry Litter and RFD = Recommended Fertilizer Dose.

Figure(s) having common letter(s) in a column did not differ significantly at 5% level of significance by DMRT.

Tillering at 210 days after transplanting

For data illustrated in Table 1, the treatment T_{15} PL @ 5 t ha^{-1} plus supplementary dose (50%) of SDRF produced significantly the highest numbers of tillers (122.07 10^3) per hectare among all the treatments at 210 DAT, but it was statistically similar to T_2, T_7, T_9, T_{10}, T_{12}, T_{13}, T_{14} and T_{16} treatments but the treatment T_1 (control) produced significantly the lowest numbers of tillers (64.60 10^3) per hectare.

Furthermore, the treatments T_{16} (PL @ 10 t ha^{-1} + 50% SDRF) and T_{14} (PL @ 3 t ha^{-1} + 50% SDRF) produced the second (119.40 10^3) and third (115.67 10^3) highest numbers of tillers per hectare, respectively.

Experimental results revealed that the tiller population significantly differed among the treatments. Maximum tiller populations (159.57 10^3) was found from the treatment T_{15}, where plant received PL @ 5 t ha^{-1} + 50 % SDRF) at 150 days after transplanting (DAT). However, minimum tiller population (64.60 10^3) was recorded in the treatment T_1 (control) at 210 DAT. Tiller populations ranged from 64.60 10^3 to 159.57 10^3 at different DAT. The highest tiller population was observed at 150 DAT and after that period, it was gradually decreased. Tiller population largely determines the productivity of the sugarcane crop. But tiller in sugarcane is influenced by many factors *viz.*, variety, soil moisture, planting time, spacing, soil nutrient supply, soil tilth and aeration, temperature and other cultivation practices observed by several researchers (Yadava, 1992; Thangavelu, 2004). In the study, it was indicated that treatments receiving both organic and chemical fertilizers increased tillers over control treatment. The increased tiller might be due to the better utilization 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.* (2009). Tiller population dynamics across the growing period indicated that tiller survivability varied from 50 to 60% in the treatments receiving both organic and chemical fertilizers. Matin *et al.* (1989) also reported that degree of survivability was between 22 to 35% when only N, P and K fertilizers were applied. In the present investigation, the tiller mortality rate was less due to the combined application of organic and chemical fertilizers.

Cane stalk height

Stalk height exhibited significant differences among the treatments (Table 2). The highest stalk height (2.80 m) was produced from the treatment T_{15} (PL @ 5 t ha^{-1} + 50 % SDRF) among all the treatments, but it was statistically similar to the treatments T_2, T_7, T_9, T_{10}, T_{12} and T_{13}. The treatment T_1 (control) produced significantly the lowest stalk height (1.47 m). Again, the treatment T_9 (CD @ 15 t ha^{-1} + 50 % SDRF) and T_{12} (MOC @ 0.5 t ha^{-1} + 50 % SDRF) produced second and third highest stalk height of 2.72 m and 2.70 m, respectively.

Cane girth

The recorded data indicated a significant difference among the treatments on cane girth (Table 2). The treatment T_{14} (PL @ 3 t ha^{-1} + 50 % SDRF) produced significantly the highest cane girth (1.96 cm) among all the treatment, but it was statistically similar to the treatments T_2, T_5, T_8 and T_{11}. The lowest cane girth (1.57 cm) was recorded from the treatment T_1 (control). Again, the treatment T_8 (CD @ 10 t ha^{-1} + 50 % SDRF) and T_{11} (MOC @ 0.25 kg ha^{-1} + 50 % SDRF) gave second and third highest cane girth of 1.95 cm and 1.92 cm, respectively.

Number of millable cane

The effects of different treatments of organic fertilizers along with inorganic fertilizers on number of millable cane showed significant variation (Table 2). Significantly the highest number of millable cane per hectare (111.70 10^3) was found from the treatment T_{15} with PL @ 5 t ha^{-1} + 50% SDRF among all the treatments, but it was statistically identical to T_7, T_9, T_{12}, T_{13}, T_{14} and T_{16} treatments. On the other hand, the treatment T_1 (control) gave significantly the lowest number of millable cane per hectare (55.50 10^3). Again, the treatment T_{14} (PL @ 3 t ha^{-1}+50% SDRF) and T_{16} (PL @ 10 t ha^{-1} + 50% SDRF) produced second (106.17 10^3) and third (104.73 10^3) highest number of millable cane, respectively.

Unit cane weight

Unit cane weight was significantly influenced by the effect of different doses of organic fertilizers (Table 2). The highest unit cane weight (1.24 kg) produced in the treatment T_9 (CD @ 15 t ha^{-1} + 50% SDRF) among all the treatments, but it was statistically similar to T_2, T_4, T_5, T_6, T_7, T_9, T_{10}, T_{12}, T_{15} and T_{16}. The treatment T_1 produced the lowest unit cane weight (0.76 kg) where the crop received no fertilizers and manures.

Table 2. Integrated of organic and inorganic fertilizers at different levels on growth, yield and yield attributes of sugarcane

Treatment	Cane stalk height (m)	Cane girth (cm)	Number of millable cane (□ 10^3 ha^{-1})	Unit cane weight (kg)	Cane yield (t ha^{-1})
T_1	1.47 g	1.57 g	55.50 f	0.76 d	42.20 h
T_2	2.65 abcd	1.86 abc	98.10 bc	1.17 ab	114.93 abcd
T_3	2.05 cdef	1.71 ef	81.13 e	1.06 bc	85.15 g
T_4	2.62 bcd	1.70 ef	91.03 cde	1.18 ab	107.11 cde
T_5	2.48 def	1.88 ab	83.37 de	1.13 abc	93.90 efg
T_6	2.58 bcde	1.78 cde	90.87 cde	1.14 abc	103.80 def
T_7	2.66 abcd	1.72 ef	99.07 abc	1.20 a	118.30 abcd
T_8	2.56 bcde	1.95 a	81.57 e	1.05 bc	86.13 fg
T_9	2.72 ab	1.76 def	102.87 abc	1.24 a	127.05 ab
T_{10}	2.65abcd	1.76 def	96.57 bcd	1.15 abc	111.39 bcde
T_{11}	2.56 bcde	1.92 a	83.67 de	1.04 bc	86.71 fg
T_{12}	2.70 abc	1.82 bcd	101.57 abc	1.23 a	124.50 abc
T_{13}	2.67 abc	1.74 def	100.83 abc	1.02 c	102.59 defg
T_{14}	2.37 f	1.96 a	106.17 ab	1.03 bc	109.89 bcde
T_{15}	2.80 a	1.68 ef	111.70 a	1.17 ab	131.55 a
T_{16}	2.41 ef	1.68 f	104.73 ab	1.13 abc	118.78 abcd
CV (%)	4.24	3.32	8.56	7.92	10.58
LSD (P=0.05)	0.178	0.098	13.29	0.146	18.35

Legend:

T_1 = Control; T_2 = GM @ 5 t ha^{-1} + 50 % SDRF; T_3 = GM @ 10 t ha^{-1} + 50 % SDRF; T_4 = GM @ 15 t ha^{-1} + 50 % SDRF; T_5 = PM @ 5 t ha^{-1} + 50 % SDRF; T_6 = PM @ 10 t ha^{-1} + 50 % SDRF; T_7 = PM @ 15 t ha^{-1} + 50 % SDRF; T_8 = CD @ 10 t ha^{-1} + 50 % SDRF; T_9 = CD @ 15 t ha^{-1} + 50 % SDRF; T_{10} = CD @ 20 t ha^{-1} + 50 % SDRF; T_{11} = MOC @ 0.25 kg ha^{-1} + 50 % SDRF; T_{12} = MOC @ 0.5 kg ha^{-1} + 50 % SDRF; T_{13} = MOC @ 1 kg ha^{-1} + 50 % SDRF; T_{14} = PL @ 3 t ha^{-1} + 50 % SDRF; T_{15} = PL @ 5 ha^{-1} + 50 % SDRF and T_{16} = PL @ 10 t ha^{-1} + 50 % SDRF.

GM = Green Manure; PM = Press Mud; CD = Cow Dung; MOC = Mustard Oil Cake; PL = Poultry Litter and RFD = Recommended Fertilizer Dose.

Figure(s) having common letter(s) in a column did not differ significantly at 5% level significance by DMRT.

Cane yield

Significant variation was observed due to different doses of organic fertilizer on cane yield as presented in Table 2. The treatment T_1 (control) produced the lowest cane yield (42.20 t ha^{-1}). The treatment T_{15} (PL @ 5 t ha^{-1} + 50% SDRF) produced the highest cane yield (131.55 t ha^{-1}) among all the treatments, but it was statistically similar to T_2, T_7, T_9, T_{12} and T_{16}. However, the treatment T_9 (CD @ 15 t ha^{-1} + 50% SDRF) produced the second highest (127.05 t ha^{-1}) and T_{12} (MOC @ 0.5 t ha^{-1} + 50% SDRF) gave the third highest (124.50 t ha^{-1}) cane yield, respectively.

Data presented in Table 2 showed that the highest growth of sugarcane stalk height (2.80 m) and cane girth (1.95 cm) were recorded from the treatment T_{15} (PL @ 5 t ha^{-1} + 50% SDRF) followed by T_9 (CD @ 15 t ha^{-1} + 50% SDRF), T_{12} (MOC @ 0.5 t ha^{-1} + 50% SDRF), T_7 (PM @ 15 t ha^{-1} + 50% SDRF) and T_2 (GM @ 5 t ha^{-1} + 50% SDRF), respectively. However, the effect was statistically identical. These results were supported by the findings of Dinesh kumar *et al.* (1996) and Kanjana *et al.* (2007). Again, the treatment PL @ 5 t ha^{-1} + 50% SDRF (T_{15}) also produced significantly the highest number of millable cane per hectare (111.70 10^3) among all the treatments, but it was statistically similar to T_7, T_9, T_{12}, T_{13}, T_{14} and T_{16} treatments. While the treatment T_1, when applied no fertilizers and manures occurred significantly the lowest number of millable cane per hectare (55.50 10^3). The weight of highest unit cane (1.24 kg) was observed from treatment T_7 (PM @ 15 t ha^{-1} + 50% SDRF, which was statistically similar to T_9, T_{12}, T_7, T_4, T_{15}, T_2, T_{10}, T_6, T_{16} and T_5 treatments. The lowest unit cane weight (0.76 kg) was obtained from the treatment T_1 that received no fertilizers and manures. Higher yield data (131.55 t ha^{-1}) produced in the treatment T_{15} (PL @ 5 t ha^{-1} + 50% SDRF and lower yield (42.20 t ha$_{-1}$) was found from the treatment T_1 (control). Among the treatments, yield data was showed statistically significant difference. The higher numbers of millable cane was obtained in organic fertilizer treated plot that attributed to less tiller mortality due to higher nutrient uptake. Significant effect of different nutrient managements on the yield of sugarcane was mainly associated with cane stalk height, cane girth and unit stalk weight.

From the result, it was revealed that same supplementary doses of recommended chemical fertilizers and organic fertilizers such as PL @ 5 t ha^{-1}, CD @ 15 t ha^{-1}, MOC @ 0.5 t ha^{-1}, GM @ 5 t ha^{-1} and PM @ 15 t ha^{-1} for sugarcane showed better yield. These results were also similar to the findings of Sharma *et. al.* (2003) and Sharma *et. al.* (2009).

Cane quality characters

Pol in cane

Data on pol in cane have been reported in Table 3, it was found that the highest pol in cane (14.73%) was noted in treatment T_3 (GM @ 10 t ha^{-1} + 50 % SDRF. The second highest value of pol in cane (14.67%) was observed among the treatments T_2 (GM @ 5 t ha^{-1} + SDRF), T_{11} (MOC @ 0.25 t ha^{-1} + SDRF), T_{12} (MOC @ 0.5 t ha^{-1} + SDRF and T_{14} (PL @ 3 t ha^{-1} + SDRF). However, the effect was found non-significant difference. Again, the lowest pol in cane (14.50%) was found from the treatments T_{10} (CD @ 20 t ha^{-1} + SDRF) and T_{16} (PL @ 10 t ha^{-1} + SDRF).

Purity

In Table 3, the highest purity (89.83 %) was obtained from the treatment T_{10} (CD @ 20 t ha^{-1} + 50 % SDRF) followed by the treatments T_2 (GM @ 5 t ha^{-1} + 50 % SDRF, T_8 (CD @ 10 t ha^{-1} + 50 % SDRF) and T_{13} (MOC @ 1 t ha^{-1} + 50 % SDRF). However, the effect was found non-significant between all the treatments. The lowest purity (89.60 %) was obtained from the treatment T_{16} where the crop received PL @ 10 t ha^{-1} + 50 % SDRF.

Phosphate

The revealed data on phosphate content in cane juice have been presented in Table 3. From Table 5, it was found that the highest phosphate content (226.00 mg L^{-1}) was found in treatments T_6 (PM @ 10 t ha^{-1} + 50 % SDRF), T_7 (PM @ 15 t ha^{-1} + 50 % SDRF) and T_9 (CD @ 15 t ha^{-1} + 50 % SDRF) followed by the treatment T_{15} (225.67 mg L^{-1}) that received PL @ 5 t ha^{-1} + 50 % SDRF. The lowest phosphate content (221.67 mg L^{-1}) was revealed from the treatments T_1 (control) and T_5 (PM @ 5 t ha^{-1} + 50 % SDRF). However, the effect was found non-significant difference among the experimental treatments.

Table 3. Integrated of organic and inorganic fertilizers at different levels on juice quality and sugar yield of sugarcane

Treatment	Pol % cane	Purity %	Phosphate ($mg\ L^{-1}$)	Reducing sugar (%)	Sugar yield ($t\ ha^{-1}$)
T_1	14.55	89.77	221.67	0.140	5.07 h
T_2	14.67	89.80	224.67	0.133	14.07 abcd
T_3	14.73	89.70	222.00	0.143	10.37 g
T_4	14.58	89.73	223.67	0.133	12.90 cdef
T_5	14.60	89.77	221.67	0.140	11.33 efg
T_6	14.60	89.63	226.00	0.137	12.57 defg
T_7	14.53	89.63	226.00	0.133	14.30 abcd
T_8	14.53	89.80	223.00	0.140	10.40 g
T_9	14.57	89.67	226.00	0.127	15.33 ab
T_{10}	14.50	89.83	223.00	0.130	13.37 bcde
T_{11}	14.67	89.77	224.00	0.137	10.50 fg
T_{12}	14.67	89.63	225.00	0.130	15.20 abc
T_{13}	14.60	89.80	222.67	0.133	12.33 defg
T_{14}	14.67	89.67	224.00	0.140	14.33 abcd
T_{15}	14.55	89.63	225.67	0.127	15.93 a
T_{16}	14.50	89.60	224.00	0.137	13.17 bcde
CV (%)	2.89	0.69	2.16	5.50	11.59
LSD (*P*=0.05)	NS	NS	NS	0.012	2.43

Legend:

T_1 = Control (native soil); T_2 = GM @ 5 t ha^{-1} + 50% SDRF ; T_3 = GM @ 10 t ha^{-1} + 50 % SDRF; T_4 = GM @ 15 t ha^{-1} + 50% SDRF ; T_5 = PM @ 5 t ha^{-1} + 50% SDRF ; T_6 = PM @ 10 t ha^{-1} + 50% SDRF ; T_7 = PM @ 15 t ha^{-1} + 50% SDRF ; T_8 = CD @ 10 t ha^{-1} + 50% SDRF ; T_9 = CD @ 15 t ha^{-1} + 50% SDRF ; T_{10} = CD @ 20 t ha^{-1} + 50% SDRF ; T_{11} = MOC @ 0.25 kg ha^{-1} + 50% SDRF ; T_{12} = MOC @ 0.5 kg ha^{-1} + 50% SDRF; T_{13} = MOC @ 1 kg ha^{-1} + 50% SDRF ; T_{14} = PL @ 3 t ha^{-1} + 50% SDRF ; T_{15} = PL @ 5 ha^{-1} + 50% SDRF and T_{16} = PL @ 10 t ha^{-1} + 50% SDRF .

GM = Green Manure; PM = Press Mud; CD = Cow Dung; MOC = Mustard Oil Cake; PL = Poultry Litter and RFD = Recommended Fertilizer Dose.

Figure(s) having common letter(s) in a column did not differ significantly at 5% level significance by DMRT.

Reducing sugars

The results in Table 3 revealed that the highest amount of reducing sugar (0.143 %) recorded in the treatment T_3 (GM @ 10 t ha^{-1} + 50 % SDRF) and the lowest amount of reducing sugar recorded in both the treatments T_9 (CD @ 15 t ha^{-1} + 50 % SDRF) and T_{15} (PL @ 5 t ha^{-1} + 50 % SDRF) with the value of 0.127 %. However, the effect was found non-significant difference among the treatments.

Sugar yield

A significant variation was observed due to the effect of different doses of organic fertilizer in respect of sugar yield (Table 3). The highest sugar yield with the value of 15.93 t ha^{-1} was found in treatments T_{15} (PL @ 5 t ha^{-1} + 50% SDRF), which was statistically similar to the treatments T_2, T_7, T_9, T_{12}, T_{14} and T_{15}. The lowest sugar yield of 5.07 t ha^{-1} was found in the control treatment (T_1).

The highest cane quality parameters *viz.*, purity (89.80%) was recorded in the treatment T_2 (GM @ 5 t ha^{-1} + 50% SDRF), pol in cane (14.73%) was found in the treatment T_3 (GM @ 10 t ha^{-1} + 50% SDRF), phosphate content (226.00 mg L^{-1}) was noted in T_6 (PM @ 10 t ha^{-1} + 50% SDRF), T_7 (PM @ 15 t ha^{-1} + 50% SDRF) and T_9 (CD @ 15 t ha^{-1} + 50% SDRF) treatments and reducing sugars (0.143%) was observed in the treatment T_3 (GM @ 10 t ha^{-1} + 50% SDRF). The lowest purity (89.60%) was mentioned in the treatment T_{16}, pol in cane (14.50%) was recorded in T_{10} and T_{16} treatments, phosphate content (221.67 mg L^{-1}) was observed in T_1 and T_5 treatments and reducing sugars (0.127%) was found in the treatment T_{15}. The highest sugar yield (15.93 t ha^{-1}) was obtained from the treatment T_{15} (PL @ 5 t ha^{-1} + 50% SDRF) while the lowest was observed in the control treatment where no fertilizers and manures used. The integrated application of organic and chemical fertilizers was found complementary effect to each other, which resulted in adequate and regular supply of macro and micro nutrient and thereby slightly increased cane yield and juice quality. Similar results were reported by Gangwar and Sharma (1997) and Bokhtiar and Sakurai (2005) in this study.

Economic analyses of using organic and inorganic fertilizers in sugarcane production

The results in Table 4 revealed that all the organic and organic fertilizer treatment combinations increased gross margin progressively over control treatment. The highest gross margin (Tk. 3,28,875.00) was obtained from the treatment T_{15} where PL @ 5 t ha^{-1} + 50% SDRF were applied in cane production. The second highest gross margin (Tk. 3,17,625.00) was recorded from the treatment T_9 where 15 t ha^{-1} CD + 50% SDRF was applied for sugarcane and the third highest gross margin (Tk. 3,11,250.00) was obtained from T_{12} treatment where 0.5 t ha^{-1} MOC + 50% SDRF was used for sugarcane production. As per benefit cost ratio (BCR), the highest value (3.80) was obtained from T_{15} treatment followed by treatments T_2 (3.63), T_7 (3.52), T_9 (3.47) and T_{12} (3.40). (3.80).

Table 4. Cost and return analysis for sugarcane cultivation with organic and inorganic fertilizers

Treatment	Gross Return ($Tk.ha^{-1}$)	Cost ($Tk.\ ha^{-1}$)			Net Profit ($Tk.ha^{-1}$)	Benefit Cost Ratio (BCR)
		Production cost	Fertilizer cost	Total cost		
T_1	105500.00	65000.00	0	65000.00	40500.00	1.62
T_2	28732500	65000.00	14060.00	79060.00	208265.00	3.63
T_3	212875.00	65000.00	16560.00	81560.00	131315,00	2.61
T_4	267775.00	65000.00	19060.00	84060.00	183715.00	3.19
T_5	234750.00	65000.00	14060.00	79060.00	155690.00	2.97
T_6	259500.00	65000.00	16560.00	81560.00	177940.00	3.18
T_7	295750.00	65000.00	19060.00	84060.00	211690.00	3.52
T_8	215325.00	65000.00	21560.00	86560.00	128765.00	2.49
T_9	317625.00	65000.00	26560.00	91560.00	226065.00	3.47
T_{10}	278475.00	65000.00	31560.00	96560.00	181915.00	2.88
T_{11}	216775.00	65000.00	19060.00	84060.00	132715.00	2.58
T_{12}	311250.00	65000.00	26560.00	91560.00	219690.00	3.40
T_{13}	256475.00	65000.00	41560.00	106560.00	149915.00	2.41
T_{14}	274725.00	65000.00	17560.00	82560.00	192165.00	3.33
T_{15}	328875.00	65000.00	21560.00	86560.00	242315.00	3.80
T_{16}	296950.00	65000.00	31560.00	96560.00	200390.00	3.08

Legend:

T_1 = Control; T_2 = GM @ 5 t ha^{-1} + 50% SDRF ; T_3 = GM @ 10 t ha^{-1} + 50% SDRF ; T_4 = GM @ 15 t ha^{-1} + 50% SDRF ; T_5 = PM @ 5 t ha^{-1} + 50% SDRF ; T_6 = PM @ 10 t ha^{-1} + 50% SDRF ; T_7 = PM @ 15 t ha^{-1} + 50% SDRF; T_8 = CD @ 10 t ha^{-1} + 50% SDRF ; T_9 = CD @ 15 t ha^{-1} + 50% SDRF ; T_{10} = CD @ 20 t ha^{-1} + 50% SDRF ; T_{11} = MOC @ 0.25 kg ha^{-1} + 50% SDRF ; T_{12} = MOC @ 0.5 kg ha^{-1} + 50% SDRF; T_{13} = MOC @ 1 kg ha^{-1} + 50% SDRF ; T_{14} = PL @ 3 t ha^{-1} + 50% SDRF ; T_{15} = PL @ 5 ha^{-1} + 50% SDRF and T_{16} = PL @ 10 t ha^{-1} + 50% SDRF .

GM = Green Manure; PM = Press Mud; CD = Cow Dung; MOC = Mustard Oil Cake; PL = Poultry Litter and RFD = Recommended Fertilizer Dose.

Cost:

Cane production cost = Tk. 65,000.00 ha^{-1}, Urea = Tk. 16.00/kg, TSP = Tk. 22.00/kg, MoP = Tk. 15.00/kg, Gypsum = Tk. 12.00/kg, Zinc sulphate = Tk. 140.00/kg, Boric acid = Tk. 120.00/kg, Magnesium sulphate = Tk. 30.00/kg, Cow dung = Tk. 1.0/kg, Press mud = Tk. 0.50/kg, Poultry litter = Tk. 2.00/kg, Mustard oil cake = Tk. 30.00/kg and Green manure = Tk. 0.50/kg.

From the experimental findings, it is concluded that different organic fertilizers such as PL @ 5 t ha^{-1}, CD @ 15 t ha^{-1}, MOC @ 0.5 t ha^{-1}, GM @ 5 t ha^{-1} and PM @ 15 t ha^{-1} accompanied with 50% SDRF showed better growth, yield and cane quality for sugarcane cultivation. As per cost and return analysis, the highest BCR (3.80) was obtained from T_{15} treatment (PL @ 5 t ha^{-1} + SDRF) as compared to all other treatments.

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