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Effect of cultivars and organic nutrient management on yield of Sugarcane and liquid jaggery (Joni Bella) in Uttar Kannada district of Karnataka

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Abstract
An experiment was conducted to study the effect of cultivars and organic nutrient management treatments on yield of sugarcane and liquid jaggery at Agriculture Research Station, Kumta, Uttara Kannada, University of Agricultural Sciences, Dharwad during 2018-19 and 2019-20. The experiment consisted three main plots (Cultivars) viz., C_1: SNK 635, C_2: Co 86032 and C_3: Konanakatte and seven sub plots (Seven nutrient management practices (NMPs) viz., N_1: Farm Yard Manure (FYM) (1/3rd) + Vermicompost (VC) (1/3rd) + Biogas slurry (BGS) (1/3rd), N_2: FYM (1/3rd) + VC (1/3rd) + Biodigester filtrate (BDF) (1/3rd), N_3: FYM (50%) + VC (50%), N_4: FYM (50%) + BGS (50%), N_5: FYM (50%) + BDF (50%), N_6: Recommended package of practices (RPP) and N_7: Farmer's practice. The results indicated that the growth and yield parameters of sugarcane were significantly influenced by cultivars and nutrient management practices and their interactions in both plant and Ratoon cane. Among the cultivars, the cultivar SNK 635 recorded significantly higher plant hight, number of tillers, number of millable canes, cane diameter, single cane weight and cane yield than Konanakatte and Co 86032 in both plant and ratoon cane. The cultivar SNK 635 recorded significantly higher liquid jaggery yield of 17.03 t ha^{-1} in plant and 15.38 tha^{-1} in ratoon cane. Organic treatments recorded significantly higher cane and liquid jaggery yield than farmers practice but on par with RPP treatment. The interactions, N_6C_1 recorded significantly higher cane and liquid jaggery yield in both plant and ratoon crop and on par with N_1C_1, N_2C_1, N_3C_1, N_4C_1 and N_5C_1.

Keywords: Cane yield, liquid jaggery, SNK 635, sugarcane and organic

Introduction

Sugarcane, a hybrid of *Saccharum* spp., is one of the major commercial crops of industrial importance next only to cotton. Globally sugarcane is cultivated on an area of 26.54 million hectares with a production of 1861 million tonnes and productivity of 70.13 tonnes ha^{-1} (Anon., 2019) [4]. India is the second largest producer of sugarcane next to Brazil. The crop sustains with an area of 4.93 m ha, production of 348.45mt and productivity of 70.70 t ha^{-1} (Anon., 2019) [4]. Karnataka state ranks 3rd in both area (0.44 m ha) production (27.38 million tonnes) with the productivity of 68.96 t/ha (Anon., 2019) [4]. Since sugarcane is a long duration and exhaustive crop producing large biomass, it removes considerable amount of nutrients from the soil for its normal growth and development. A crop of 100 tonnes cane yield may remove 140 kg N, 34 kg P and 332 kg K from the soil (Dang *et al.*, 1995) [7]. Though sugarcane produce is utilized mainly for sugar production with enough number of sugar factories, nearly 40 percent of sugarcane is being diverted to jaggery industry indicating its importance. There are three types of jaggery namely solid jaggery, liquid jaggery and granular jaggery. Liquid jaggery is alternative source to honey. It is an intermediate product collected during jaggery manufacturing and striking temperature of it ranges from 105 °C to 108 °C or generally it depends upon the cultivars of sugarcane used. Liquid jaggery is used in many ayurvedic preparations from times immemorial. It is widely used as sweetening agent in Karnataka, Maharashtra, Tamil Nadu, Gujarat, Andhra Pradesh and Kerala states. It is commercially used in various food industries and pharmaceutical formulations (Chikkappaiah, 2017) [6]. In Uttara Kannada district, except Haliyala and Zoida Taluks, sugarcane is grown only for making liquid jaggery which is known as "Joni bella". Farmers grow sugarcane on a small area and make jaggery for domestic use every year. The yield of cane and liquid jaggery depends on juice quality, soil type, cultivars, nutrient management and processing methods. Major constraint with sugarcane cultivation and liquid jaggery making is poor yield.

Hence, study was conducted on effect of cultivars and organic nutrient treatments on yield of sugarcane and liquid jaggery. The objective of study was to find suitable cultivar and organic nutrient source for higher yield of sugarcane and liquid jaggery.

Material and Methods

An experiment was conducted to study the effect of cultivars and nutrient management practices on yield of sugarcane and liquid jaggery at Agriculture Research Station, Kumta, Uttara Kannada of University of Agricultural Sciences, Dharwad during 2018-19 and 2019. It lies in Coastal zone of Karnataka (Zone-10) and Region II of Agro-climatic zones of India. The experimental site was located at 14° 25' North latitude and 74° 25' East longitude with an altitude of 24.2 m above the mean sea level. The District is high rainfall area coming under malnad region. The average rainfall of the location for the past 23 years is 3722.28 mm, which is distributed over a period of six months from June to October with peaks during June, July and August (999.65,1088.14 and 775.71 mm, respectively. The soil of the experimental site was sandy loam, belonged to the order alluvial soils.

The experiment consisted three main plots (Cultivars) viz., C_1-SNK 635, C_2-Co 86032 and C_3-Konanakatte local cultivar and seven sub plots (seven nutrient management practices (NMPs) viz., N_1: Nutrient management practices through the application of 100 percent organics equivalent to recommended dose of nitrogen [(1/3rd through FYM as basal + 1/3rd through Vermicompost (VC in two splits at 90 and 120 DAP)] + 1/3rd through Biogas slurry applied in eight split at an interval of 15 days from 90 days to 120 and 180 to 240 days after planting (DAP)/days in ratoon (DIR), N_2: Nutrient management practices through addition of 100 percent organics equivalent to recommended dose of nitrogen [1/3rd through FYM as basal + 1/3rd through VC in two splits applied at 90 and 120 DAP +1/3rd through Bio-digester filtrate (BDF) applied in five split at an interval of 15 days from 90 to 120 and 180 to 240 DAP/DIR, N_3: Nutrient management practices through addition of 100 percent organics equivalent to recommended dose of nitrogen (50 percent through FYM as basal + 50 percent through VC at 90 and 120 DAP/DIR), N_4: Nutrient management practices through addition of 100 percent organics equivalent to recommended dose of nitrogen (50 percent through FYM as basal + 50 percent through Biogas slurry in eight splits at an interval of 15 days from 90 days to 120 and 180 to 240 days after planting (DAP/DIR), N_5: Nutrient management practices through addition of 100 percent organics equivalent to recommended dose of nitrogen (50 percent through FYM as basal + 50 percent through the application of BDF in 10 splits from 90 to 120 and 180 to 240 DAP /DIR), N_6: Recommended package of practices (RPP) and N_7: Farmers' practice. The experiment was laid out in strip block design with three replication. The plot size was 7.2 m X 14.1 m. The single eye budded sets of 10 months old cane were planted in furrows on 23rd march, 2018 and crop was harvested after 365 days. The crop was harvested to the ground level and detrashed, bundled and stacked before recording the plot yield. A recommended dose of dolomite (500 kg/ha) during land preparation and farm yard manure 25 t/ha^{-1} were given. Nitrogen, phosphorus and potassium fertilizers were applied as per the treatments in the form of urea, rock phosphate and muriate of potash, respectively and micronutrient was applied in the form of $ZnSO_4$ @ 25 kg ha^{-1} as soil application.

Details of Organic Nutrient Management Practices (For N_1 to N_5)

- Nutrients were supplied through FYM, VC, Biogas slurry and BDF as per the treatment equivalent to 100 percent N over the recommended dose of FYM (*i.e.* 25 t ha^{-1}).
- Soil application of Phosphorus solubilizing bacteria (PSB) @ 10 kg ha^{-1} mixed with FYM. (To augment P availability).
- Neem cake @ 250 kg ha^{-1} (As a bio insecticide)
- *Metarhizium anisiopliae* @ 10 kg ha^{-1} by mixing with FYM (As a bio insecticide)
- *Glucanacetobacter* @ 4 lit ha^{-1} (for set treatment at planting)
- *Glucanacetobacter* used as foliar spray @ 5 percent at 30 DAP
- Panchagavya liquid organic manure used as foliar spray @ 3 percent at 60 and 90 DAP (as a source of nutrient and growth promoter)
- Spray of NSKE 0.5 percent (As a bio insecticide)

Details of RPP (Recommended Package of Practices) For S_6

- FYM @ 25 t/ha^{-1} applied in furrows before planting.
- Recommended dose of fertilizers: 186:125:125 kg N: P_2O_5: K_2O ha^{-1}
- Bio-fertilizers: *Azospirillium* and Phosphorus solubilizing bacteria (PSB) @ 10 kg/ha mixing through FYM.
- Micronutrients: Soil application of $ZnSO_4$ @ 25 kg/ha.

Salient features of the cultivars

SNK 635: Parentage Co 8013 Poly cross, midlate (11-12 months) with fast growth, high yielding, sugar rich variety superior over Co 86032, non-flowering with excellent field capacity, medium thick erect canes with dark green colour canopy, high tillering, suitable for high rainfall areas and lateritic /acid soils and suitable for solid jaggery, liquid jaggery and sugar production.

Co 86032: Parentage: Co62198 x CoC671, duration of 11-12 months largely cultivated by farmers, responds very well to all sources of nutrients, suitable for solid jaggery, Sugar and liquid jaggery (Joni bella) production, sweeter than Konanakatte local cultivar, high tillering, high yielding and quality cane variety with excellent ratooning ability, reddish pink (exposed) greenish yellow (unexposed) coloured medium thick canes with broad green root zone and green purple leaf sheath, self detrashing in nature, late and very sparse flowering (< 5 percent), hence longer field keeping quality.

Konanakatte: It is local midlate local variety with duration of 11-12 months, cultivated by farmers of Uttara Kannada and Shimoga district of Karnataka, soft cane with medium sweetness with higher moisture content, pinkish blue cane, suitable for liquid jaggery production.

Imposition of treatments

The combination of three sugarcane cultivars were allotted to the main plots and seven nutrient supply systems were allotted to the sub plots. Sett treatment was done with *Gluconacetobacter* (N_1 to N_5). However, for 100 percent inorganics and RPP treatments, chemical sett treatment was done for 10 minutes with Urea @ 1 gL^{-1} carbendazim @ 1 gL^{-1} and chlorpyriphos @ 1 ml L^{-1}. The organic manures viz., farmyard manure, vermicompost, Biodigester extract and bio gas slurry were analysed for their nutrient content before application for making N equivalent nutrient application (Table 1). The organic manures were applied to treatments N_1 to N_5 at the time of planting of sugarcane and as per the treatments. Biofertilizers viz., *Azospirillum* and Phosphorus solubilizing bacteria @ 10 kg ha^{-1} each were applied along with the organic manures at the time of application of organic manures to organic treatments (N_1, N_2 N_3, N_4 and N_5) and RPP (N_6). The farm yard manure was applied as per the farmer practice to farmer practice treatments (N_7). Organic liquid manures like Panchagavya was applied as foliar spray @ 3 percent at 60 and 90 DAP to all the organic treatments (N_1, N_2 N_3, N_4 and N_5). The inorganic fertilizers were applied as per the recommendation to RPP treatments (N_6) and manures applied to farmers practice treatments (N_7) as per the farmers practice.

Procedure for preparation of organic formulations

Panchagavya: Panchagavya was prepared by using 7 kg fresh desi cow dung and 1 kg ghee mixed thoroughly and kept for 2 days. It was thoroughly mixed daily thrice. After 2 days, 4 L cow urine + 10 L water was added and allowed to ferment for 10 days by stirring daily twice. Then 2 L of cow milk, 2 L of curds, 3 L of sugarcane juice or 250 g jaggery, 2 L of coconut water, and 12 ripened banana was added and further the mixture was allowed to ferment for another 15 days. The contents were stirred daily at least 2-3 times. The solution was filtered and used as foliar spray at the rate of 3 percent concentration.

Table 1: Nutrient composition (%) of organic manures used in the experiment [farm yard manure (FYM), vermicompost (VC), bio-digester filtrate (BDF) and Biogas slurry before planting / ratooning]

Nutrient (percent)	FYM	VC	Bio-gas slurry	BDF
Nitrogen	0.65	1.24	1.12	1.05
Phosphorus	0.23	0.72	0.82	0.68
Potassium	0.68	0.95	0.96	0.64
Calcium	2.03	5.50	1.56	1.00
Magnesium	0.89	2.89	0.59	0.30
Zinc	0.009	0.012	0.018	0.016
Copper	0.006	0.04	0.03	0.01
Iron	0.192	0.35	0.3	0.26
Manganese	0.041	0.08	0.05	0.06
Sulphur	1.09	3.12	0.89	0.50

Observations recorded

Growth and Yield parameters

Plant height

The height of five randomly selected canes in each clump treatment wise was recorded at harvest. The plant height was measured from the base of the plant to the fully opened top leaf auricle. The mean height was recorded as plant height in cm.

Number of tillers ('000 ha^{-1})

The green tillers present in each plot were counted and recorded as number of tillers at 180 days after planting and expressed in thousands per ha.

Diameter of cane

The diameter of cane was recorded at harvest of the crop. This was recorded by using Digital Vernier callipers and expressed in cm. The diameter at top, middle and bottom portion of cane was measured and averaged.

Average length of internodes

The millable cane height measured at harvest was divided by number of internodes of each cane and recorded as average inter nodal length and expressed in centimetre.

Number of millable canes ('000 ha^{-1})

At harvest, harvesting was done, detrashed, tops removed and counted and recorded as number of millable canes per plot. These were expressed as number of millable canes per ha based on plot size.

Single cane weight

The single cane weight was recorded at harvest, the weight of five millable canes was recorded and the average was worked out and expressed as single cane weight in kilogram.

Cane yield

All the canes in the net plot from each treatment were cut close to the ground level. The green tops and trash were removed and cane yield per plot was recorded at harvest and expressed as t/ha^{-1}.

Liquid jaggery parameters

Liquid Jaggery yield: Liquid Jaggery yield (Joni bella) was recorded after making and expressed in t ha^{-1}.

Jaggery recovery (%): Liquid jaggery recovery percent was calculated by below formula.

$$\text{Jaggery recovery (\%)} = \frac{\text{Jaggery yield (t)}}{\text{Cane weight (t)}} \times 100$$

Results and Discussion

Plant height (cf. Table 2)

The cultivars and nutrient management practices (NMPs) had significant influence on sugarcane plant height of both plant and ratoon cane. Both SNK 635 and Co 86032 recorded significantly higher plant height than check variety Konanakatte. The cultivar SNK 635 recorded significantly higher plant height (295.5 cm) than Co 86032 (260.7 cm) and Konanakatte (218.9 cm) in plant cane. Organic nutrient management practices in plant cane (N_1 to N_5) (266.6, 263.0, 264.3, 270.2 and 260.0 cm, respectively) and RPP (272.8 cm) recorded significantly higher plant height compared to farmer's practices (211.7 cm). Plant height recorded in organic nutrient management practices (N_1 to N_5) were on par with RPP treatment. Interaction effect of different cultivars and nutrient management practices had significant influence on plant height of plant cane. Interactions of cultivars and nutrient management practices showed that, all cultivars, recorded significantly higher plant height with respective RPP

(N_6) treatment and organic nutrient treatments (N_1 to N_5) compared to farmer's practice treatment. Significantly higher plant height was recorded with cultivar SNK-635 with RPP treatment (310.6 cm) and on par with SNK 635 with organic nutrient treatments (N_1 to N_5) (304.3, 301.9, 303.2, 308.0, and 299.3 cm, respectively) and Co 86032 of RPP treatment (274.5 cm). Significantly lower plant height was recorded in all three cultivars (241.4, 212.6 and 181.1 cm in SNK 635, Co 86032 and Konanakatte, respectively) with farmer's practices treatment. The lowest plant height was recorded in cultivar Konanakatte receiving farmers practice treatment (181.1 cm). Similar trend of plant height of cane was observed in ratoon also.

Number of tillers (cf. Table 2)

Number of tillers of both plant and ratoon cane was significantly influenced by cultivars and nutrient management practices. Among the cultivars, SNK 635 recorded significantly higher number of tillers (97.0 thousands ha^{-1}) than CO 86032 (78.4 thousands ha^{-1}) and Konanakatte (59.5 thousands ha^{-1}). Organic nutrient management practices (N_1 to N_5) (80.4, 78.8, 79.8, 83.4 and 78.3 thousands $ha^{-1,}$ respectively) and RPP treatment (86.5 thousands ha^{-1}) recorded significantly higher number of tillers than farmer's practice (61.0 thousands ha^{-1}) among the nutrient management treatments. However, organic nutrient treatment N_1 to N_5 were on par with RPP treatment. Similar observations were noticed in ratoon cane also. Significantly higher number of tillers was recorded in interaction with organic nutrient practices and RPP treatment irrespective of cultivars compared to farmers practice. All the interactions involving organic nutrient management practices from N_1 to N_5 of SNK 635 and Co 86032 cultivars were on par with RPP treatment of same cultivars for number of tillers. Significantly lower number of tillers was recorded in cultivar Konanakatte of all nutrient management practices and lowest with Konanakatte cultivar with farmers practice (49.1 thousands ha^{-1}). Same trend was recorded in ratoon cane also.

Cane diameter (cf. Table 3)

Cane diameter of both plant cane and ratoon cane did not differ significantly due to cultivars, nutrient management practices and their interaction effects.

Internodal length (cf. Table 3)

Different cultivars and nutrient management practices had significant influence on internodal length of Sugarcane in both plant and ratoon cane. Intermodal length of sugarcane differed significantly among the cultivars in plant cane. The cultivar SNK 635 recorded significantly higher internodal length (10.22 cm) than Konanakatte (8.29 cm) but on par with Co 86032 (10.17 cm). Organic nutrient management practices (N_1 to N_5) (9.80, 9.75, 9.75, 9.89, and 9.70 cm, respectively) and RPP (10.03 cm) recorded significantly higher internodal length compared to famer's practices (7.99 cm). Internodal lengths recorded in organic nutrient management practices (N_1 to N_5) were on par with RPP treatment. Interaction effect of cultivars and nutrient management practices had significant influence on internodal length. Interactions among the cultivars and nutrient management practices showed that, cultivar SNK 635 with RPP treatment (C_1N_6) recorded internodal length of 10.70 cm and on par with all other interactions except cultivar Konanakatte with farmer's practice (C_3N_7) (7.00 cm). Ratoon cane also expressed similar trend with respect to internodal length as observed in plant cane.

Number of millable canes (NMC) (cf. Table 4 and Fig 1& 2)

The number of millable canes differed significantly among the nutrient management practices, cultivars and interaction effect of nutrient management practices and cultivars. Among cultivars, significantly higher number of millable canes recorded with SNK 635 (94.1 thousand ha^{-1}) than Co 86032 (75.7 thousand ha^{-1}) and Konanakatte (57.5 thousand ha^{-1}) in plant cane. Konanakatte cultivar recorded significantly lower number of millable canes than other two cultivars. Organic nutrient management practices (N_1 to N_5) (77.9, 76.2, 77.2, 80.8 and 75.6 thousand ha^{-1}, respectively) and RPP (83.8 thousand ha^{-1}) recorded significantly higher number of millable canes as compared famer's practices (58.9 thousands ha^{-1}). The number of millable canes recorded in organic nutrient management practices (N_1 to N_5) were on par with RPP treatment. Interaction effect of different cultivars and nutrient management practices had significant influence on number of millable canes. Interactions among the cultivars and nutrient management practices showed that, all tested cultivars, recorded significantly higher number of millable canes with respect to RPP (N_6) and organic nutrient practices (N_1 to N_5) compared to farmer's practice treatment. Significantly higher number of millable cane was recorded with cultivar SNK 635 (101.9 thousand ha^{-1}) with RPP treatment and on par with SNK 635 cultivar with organic nutrient treatments (N_1 to N_5) (97.0, 95.3, 96.6, 98.3 and 95.0 thousands ha^{-1}, respectively) and RPP of Co 86032 (86.4 thousands ha^{-1}). Significantly lower number of millable cane was recorded in Co 86032 (55.1 thousand ha^{-1}) and Konanakatte cultivar (47.1 thousand ha^{-1}) of farmer's practices treatment. The lowest number of millable cane was recorded in cultivar Konanakatte receiving farmer's practice treatment (47.1 thousand ha^{-1}). The same trend followed in ratoon cane as that of plant cane for number of millable canes.

Single cane weight (cf. Table 4 and Fig 1&2)

Cultivars, nutrient management practices and interaction effect of nutrient management practices and cultivars had significant influence on single weight of sugarcane in both plant and ratoon cane. SNK 635 recorded significantly higher single cane weight (1.38 kg $cane^{-1}$) than Konanakatte (1.13 kg $cane^{-1}$) but it was on par with cultivar Co 86032 (1.32 kg $cane^{-1}$). In plant cane, organic nutrient management practices (N_1 to N_5) (1.32, 1.30, 1.31, 1.35 and 1.28, kg $cane^{-1}$, respectively) and RPP (1.35 kg $cane^{-1}$) recorded significantly higher single cane weight compared to famer's practices (1.03 kg $cane^{-1}$). The single cane weight recorded in organic nutrient management practices (N_1 to N_5) was on par with RPP treatment. Interaction effect of different cultivars and nutrient management practices had significant influence on single cane weight in plant cane. Interactions among the cultivars and nutrient management practices indicated that, significantly higher single cane weight was recorded with SNK 635 with RPP treatment (C_1N_6) (1.44 kg $cane^{-1}$) and found on par with all interactions except cultivar Co 86032 (1.02 kg $cane^{-1}$) (C_2N_7) and Konanakatte (C_3N_7) (0.92 kg $cane^{-1}$) with farmer's practice. Similar results were obtained with respect to single weight in ratoon cane also.

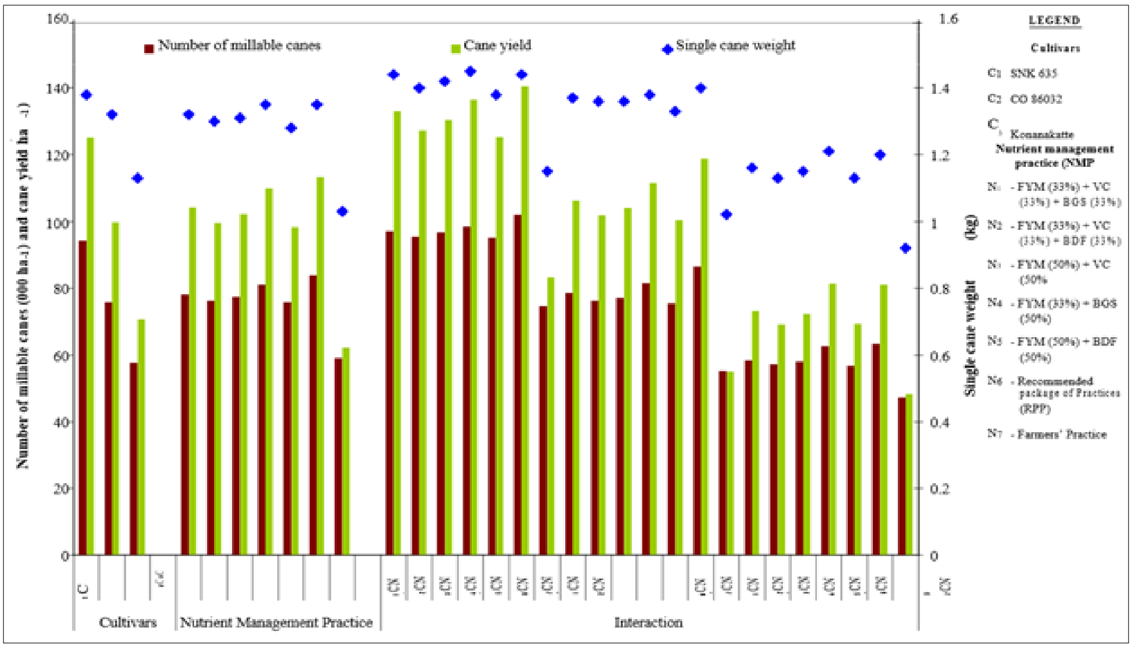

Fig 1: Cane yield and yield parameters of plant cane as influenced by organic, integrated nutrient management practices and cultivars

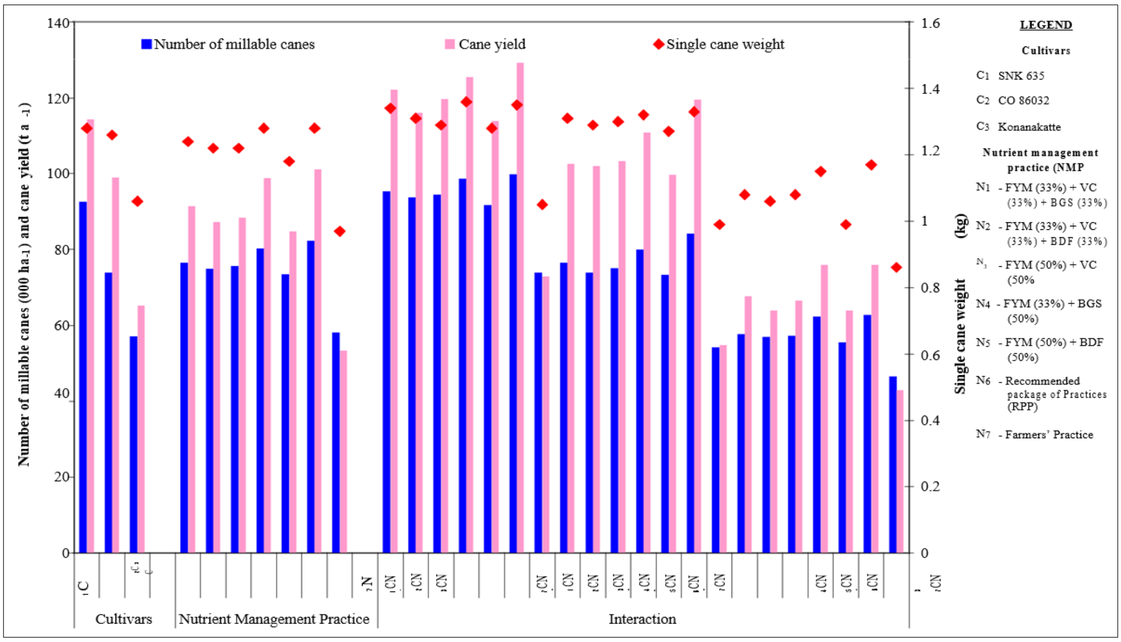

Fig 2: Cane yield and yield parameters of ratoon cane as influenced by organic, integrated nutrient management practices and cultivars

Cane yield (cf. Table 5 and Fig 1 &2)

The cane yield was significantly influenced by cultivars, nutrient management practices and their interactions in both plant and ratoon cane. In plant cane, the sugarcane cultivar SNK 635 recorded significantly higher cane yield (125.03 t ha^{-1}) than Co 86032 (99.62 t ha^{-1}) and Konanakatte (70.57 t ha^{-1}). Significantly lower cane yield was reported in cultivar Konanakatte (70.57 t ha^{-1}). The Cane yield increase in SNK 635 cultivar to an extent of 77.17 and 25.51%, respectively over Konanakatte and Co-86032 in plant cane. Whereas, in ratoon cane, % increase in cane yield of SNK 635 were 75.07 and 15.46% over Konanakatte and Co 86032, respectively. Similar variation in cane yield among sugarcane cultivars were reported by Kadam *et al.* (2005) [11], wherein mid late cultivar Co 86032 out yielded Co 92005. Similar results of higher yield with mid late cultivars were also reported by Aluri (2013) [1], Manimaran and Kalyanasundaram (2006) [17] and Kuri and Chandrashekhara (2015) [14]. The higher cane yield recorded with cultivar SNK 635 was owing to significantly higher yield attributing characters viz., number of millable canes, single cane weight in both plant and ratoon cane compared to Co- 86032 and Konanakatte. The results are in conformity with the findings of Kuri and Chandrashekhara (2015) [14], who reported that mid late cultivar CoSnk 05104 showed higher yield attributing characteristics viz., number of millable canes and single cane weight for higher cane yield. Nooli (2019) [21] reported significant yield attributing traits which were higher in SNK 07680 than SNK 09211. The plant height, internodal and cane girth are the important yield attributing traits which were higher in SNK 635 than Co 86032 and Konanakatte in both plant and ratoon cane. Findings of the present study are in tune with Aluri (2013) [1] and Kuri and Chandrashekhara (2015) [14]. The increased photosynthetic efficiency of cultivar SNK 635 reflects on early vigour of the crop which resulted in higher number of tillers over Co 86032 and Konanakatte. Similar findings were reported by Sunilkumar nooli (2019) [21] and Kuri and Chandrashekhara (2015) [14].

Nutrient management practices influenced significantly on cane yield compared to farmers practice treatment. Among organic nutrient management practices, cane yield recorded in FYM (50%) + Biogas slurry (50%) (109.73 t ha^{-1}), FYM (33%) + Vermicompost (33%) + Biogas slurry (33%) (104.01 t ha^{-1}), FYM (50%) + Vermicompost (50%) (102.15 t ha^{-1}), FYM (33%) + Vermicompost (33%) + Biodigester filtrate (33%) (99.35 t ha^{-1}) and FYM (50%) + Biodigester filtrate (50%) (98.20 t ha^{-1}) was found to be on par with each other. All the organic treatments recorded on par cane yield with RPP treatment (113.31 t ha^{-1}). Significantly lower cane yield was with farmers practice (62.08 t ha^{-1}). There was 68.3 and 72.54% increase in yield in all the nutrient management practice treatments over farmers practice in plant and ratoon cane, respectively. Significantly superior yield (58.51 t ha^{-1}) was recorded with application of FYM equivalent to N recorded over the control treatment (Yogananda *et al.*, 2014) [24]. Sivaraman *et al.* (2013) [24] conducted long term experiment for comparing organic treatment with convention system. He obtained results that there were no significant difference in the data on number of millable cane, single cane weight, cane diameter, growth parameters and cane yield between organic and convention system of sugarcane production. Significantly lower cane yield was with farmers practice. Application of Biogas slurry @10 t ha^{-1} recorded significantly superior cane yield (54.8 t/ha) over control (24.8 t ha^{-1}) and trash @10 t ha^{-1} + Trichoderma (40.0 t ha^{-1}) and it was on par with vermicompost @10/ha^{-1}, FYM @ 10 t/ha, Dhiancha + Acetobacter, and NPK 120:60:60 kg/ha (Anon., 2008) [2]. Organic treatments containing biogas slurry and vermicompost had recorded higher growth and, yield and yield attributing parameters than other organic sources. Biogas slurry contains easily available plant nutrients and it contains higher amounts of nutrients and macronutrients than composted manure and FYM (Ishikawa *et al.*, 2006) [10]. Effect of biogas slurry application is comparable to the effects of the application of synthetic fertilizers (Sandeep kumar *et al.*, 2015) [18]. During digestion of biogas slurry, nutrients are transferred from organic form to dissolved state inorganic form, making them useful for plant uptake (Lansing *et al.*, 2010) [16]. This is the significant for nitrogen, where the organic nitrogen is released as ammonium, which is readily available for the crops. It reduces the need for applying additional mineral nitrogen fertilizers and it can decrease the ammonia volatilization and nitrate leaching, mitigating environmental impact. Sunilkumar nooli (2019) [21] reported that cane yield of organic nutrient management practices viz., 100 percent organics equivalent to RDN through FYM (33%) + IGM (17%) + VC (50%) (N_1) and 100 percent organics equivalent to RDN through FYM + VC + BDF (1/3rd each) (N_2) were on par with each other and in ratoon cane all the organic nutrient management practices were on par with each other. Giraddi (1993) [9] reported 0.8, 1.1 and 0.5 percent N, P_2O_5 and K_2O, respectively in vermicompost. The vermicompost contained two times more N and four times more P_2O_5 and K_2O in comparison with FYM. Biogas slurry and vermicompost has significant potential to improve the physical and biological quality of soil (Improvement in soil structure, improvement in water holding capacity, cation exchange capacity, lesser soil erosion and provision of nutrients to soil micro-flora including nitrogen fixing and phosphorous solubilizing organisms) besides providing both macro and micro-nutrients to crops. Yield increases due to biogas slurry application, have also reported for many crops including field crops, tobacco, castor, peas, mustard, onion, cabbage, banana, chilli, pearl millet and sugarcane (Kumar *et al.*, 2015) [13]. He also reported that there was 6.5, 8.9, 15.2 and 15.7% increase in yield of cotton, wheat, maize and rice, respectively. Similar report was made by Umesh *et al.*, (2018) [23] and established that number of tillers, number of millable canes and sugarcane yield with application of Biogas Slurry.

The higher cane yield recorded with all nutrient management practice treatments in both plant and ratoon crops was mainly attributed to the better yield attributing characters like significantly higher number of millable canes and single cane weight as compared to farmer practice. The better performances of yield attributing characters responsible for increased cane yield in N_1 to N_6 in both plant and ratoon cane are in line with the findings of Keshavaiah (2011) [12]. Application of nutrients as per RPP recorded significantly higher yield attributing characters in plant cane over the application of 100 percent organics (N_1 and N_5) at all the growth stages. This might be ascribed to increased availability of nutrients throughout growing period through the application of nutrients through treatments and trash also.

Bhalerao *et al.* (2006) [5], Deshmukh *et al.* (2014) [8] and Sinha *et al.* (2014) [19], they had opinion that the nutrient supply through integration of organics and chemical fertilizers accomplished the twin objectives of slow mineralization of nutrients and making them available at different stages through organic source and readily available at higher concentration through chemical fertilizers. This might be due to the fact that biogas slurry, vermicompost and biodigester filtrate (BDF) are good sources of nutrients viz., organic carbon, nitrogen, phosphorus, potassium and micronutrients (Zn, Cu, Fe and Mn). It also enriches the soil in terms of organic matter which improves the physical properties of the soil. Increase in the available nitrogen with application of biogas slurry, vermicompost, biodigester filtrate and farmyard manures may be attributed to the incorporation of organic matter which enhances the multiplication of microbes for the conversion of organically bound N to inorganic form (Sinha *et al.*, 2014) [19]. Hence, Growth and yield attributing charecters are improved in RPP and Organic treatments.

The interaction effect of cultivars and nutrient management practices was found significant influence on cane yield. Among interactions, cultivar SNK 635 with RPP treatment (C_1N_6) recorded significantly higher cane yield of 140.29 t ha^{-1} and found on par with C_1N_4 (136.41 t ha^{-1}), C_1N_1 (132.62 t ha^{-1}), C_1N_3 (130.34 t ha^{-1}), C_1N_2 (127.09 t ha^{-1}), C_1N_5 (125.12 t ha^{-1}) and C_2N_6 (118.66 t ha^{-1}). Whereas, significantly lower cane yield was recorded in C_3N_7 (48.20 t ha^{-1}) and C_2N_7 (55.01 t ha^{-1}) interactions. Data recorded on cane yield of cultivars, nutrient management treatments and interaction effects in ratoon cane showed similar trend of result. Similar interactions were reported by Nooli (2019) [21] and Aluri, (2013) [1].

Liquid jaggery yield (cf. Table 5 and Fig 3 & 4)

Liquid jaggery yield was significantly influenced by nutrient management practices, cultivars and their interaction in both plant and ratoon cane. SNK 635 recorded significantly higher liquid jaggery yield (17.03 t ha^{-1}) than Co 86032 (13.52 t ha^{-1}) and Konanakatte cultivar (9.24 t ha^{-1}) among cultivars in plant cane. The cultivar Konanakatte recorded significantly lower liquid jaggery yield (9.24 t ha^{-1}). SNK 635 recorded 84.31 and

25.96% increase in liquid jaggery yield over Konanakatte and Co-86032, respectively in plant cane. Similarly in ratoon cane, liquid jaggery yield increased in SNK 635 to an extent of 81.80 and 14.18% over Konanakatte and Co 86032. Konanakatte recorded significantly lower liquid jaggery yield in both plant and ratoon cane. Swamy Gowda *et al.* (2014) reported that, the genotype, VCF 0517 possessed higher cane sugar and jaggery yield potential. It was superior compared to standard checks Co 62175 and Co 86032. Nooli (2019) [21] revealed that cultivars SNK 07680 and SNK 09211 recorded higher jaggery recovery and jaggery yield. Significantly higher liquid jaggery yield in SNK 635 and Co 86032 was due to increased cane yield (Table 5) and increased jaggery recovery% (Table 6) than Konanakatte cultivar. Similar opinion was made by Nooli (2019) [21] and Aluri (2013) [1].

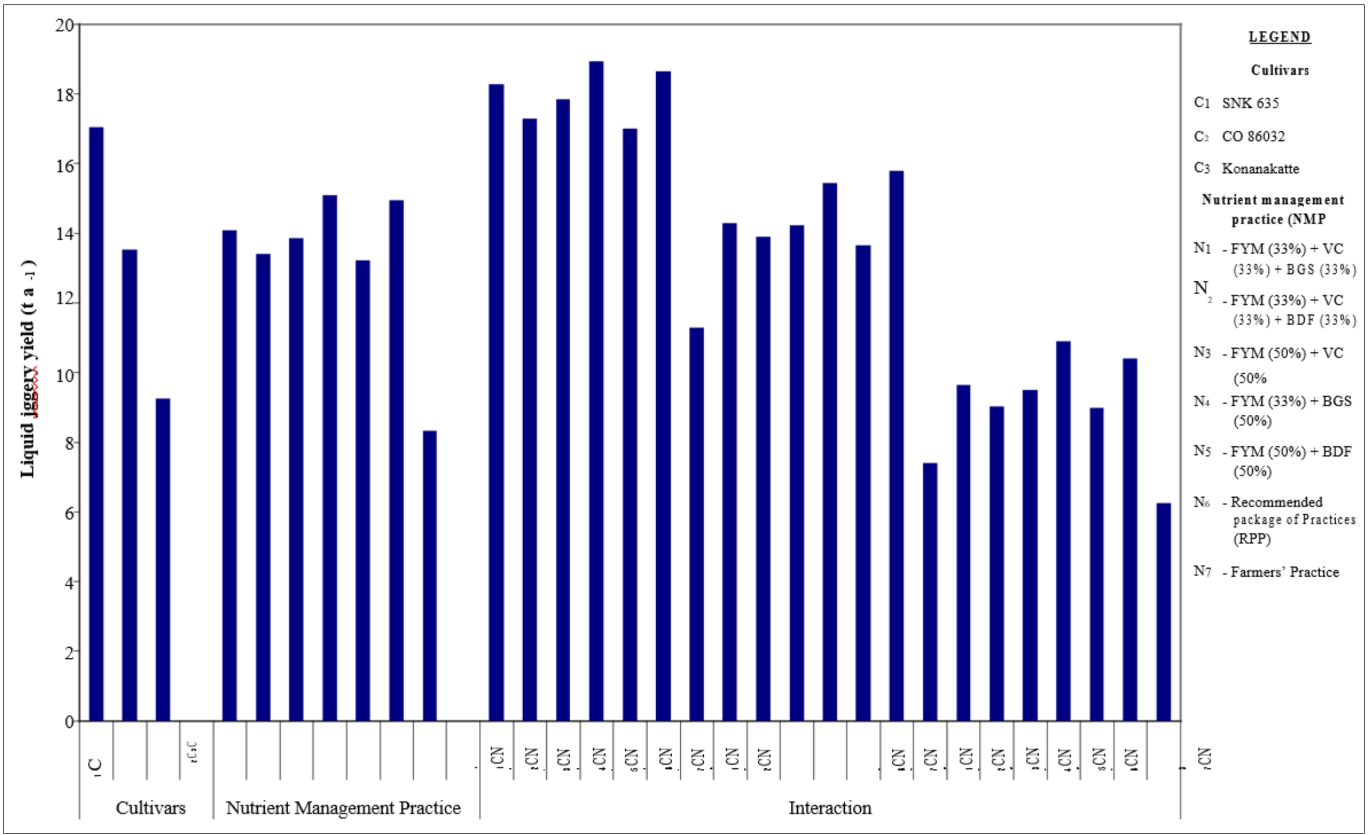

Fig 2: Liquid Jaggery yield of plant cane as influenced by organic, integrated nutrient management practices and cultivars

Nutrient management practices (N_1 to N_6) recorded significantly higher liquid jaggery yield compared to farmers practice treatment. Liquid jaggery yield of plant cane recorded in organic nutrient management practices (N_1 to N_5) (14.06, 13.40, 13.85, 15.09, and 13.21 t ha^{-1}, respectively) was on par with RPP treatment (N_6) (14.94 t ha^{-1}). Significantly lower liquid jaggery yield (8.31 t ha^{-1}) was with farmers' practice (N_7). There was 68.83 and 75.73% increased liquid jaggery yield in nutrient management practices (N_1 to N_5) over farmers practice in plant and ratoon cane, respectively. Liquid jaggery yield recorded in all organic nutrient management practices (N_1 to N_5) were on par with RPP treatment. Significantly lower liquid jaggery yield was with farmers' practice (N_7). Significant higher liquid jaggery yield in nutrient management practice treatments was due to significant increase cane yield and increased jaggery recovery percent. Nutrient management practices recorded jaggery recovery ranged from 13.13 to 13.70 percent in plant cane and 12.99 to 13.63% in ratoon cane. The field trials conducted by Lal Chand Malav *et al.* (2015) indicating that 50% biogas slurry along with 50% chemical fertilizer gave 20% more yield in terms of maize cob as well as biomass. Nooli (2019) [21] recorded RPP resulted in significantly higher jaggery yield and with the application of 100 percent organics which were on par with each other in both plant and ratoon cane.

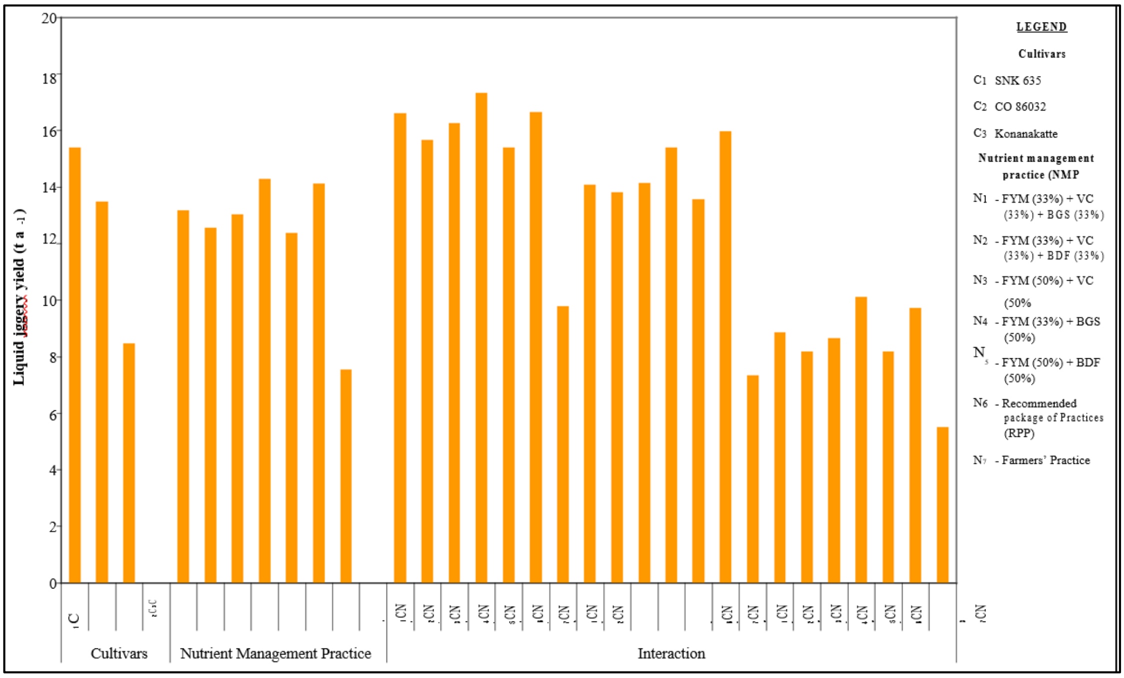

Fig 2: Liquid Jaggery yield of ratoon cane as influenced by organic, integrated nutrient management practices and cultivars

The interaction effect of cultivars and nutrient management practices influenced significantly on liquid jaggery yield in both plant cane and ratoon cane liquid jaggery. Among interactions, cultivar SNK 635 with RPP treatment (C_1N_6) recorded significantly liquid jaggery yield of 18.63 t ha^{-1} and found on par with C_1N_4 (18.93 t ha^{-1}), C_1N_1(18.27 t ha^{-1}), C_1N_3 (17.83 t ha^{-1}), C_1N_2 (17.29 t ha^{-1}), C_1N_5 (17.00 t ha^{-1}), C_2N_6 (15.78 t ha^{-1}) and C_2N_4 (15.44 t ha^{-1}). Whereas, significantly lower liquid jaggery yield was recorded in C_3N_7 (6.25 t ha^{-1}) and C_2N_7 (7.39 t ha^{-1}) interactions. The liquid jaggery yield recorded in ratoon cane was also significantly influenced by nutrient management practices, cultivars and their interaction and showed similar trend of plant cane. Significant increase of liquid jaggery yield in these interactions was due to improvement in cane yield and jaggery recovery.

Liquid jaggery recovery % (cf. Table 6)

Liquid jaggery recovery in plant and ratoon cane did not differ significantly due to cultivars, nutrient management practices and their interaction effect. However, jaggery recovery ranged from 13.13 to 13.70% in plant cane and 12.99 to 13.63% in ratoon cane.

Table 2: Plant height (cm) and Number of tillers of Sugarcane as influenced by organic, integrated nutrient management practices and cultivars

Vertical strips [Nutrient management practice (NMP)]		Plant height (cm)								Number of tillers ('000 per ha)							
		Plant Cane				Ratoon Cane				Plant Cane				Ratoon Cane			
		Horizontal strips (Cultivars)															
		C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
N_1	FYM (33%) + VC (33%) + BGS (33%)	304.3	268.3	227.2	266.6	305.0	262.6	228.5	265.4	100.0	80.8	60.3	80.4	103.0	83.8	63.3	83.3
N_2	FYM (33%) + VC (33%) + BDF (33%)	301.9	265.9	221.1	263.0	299.2	263.3	222.5	261.6	98.3	79.1	59.1	78.8	100.3	81.1	61.1	80.8
N_3	FYM (50%) + VC (50%	303.2	267.1	222.6	264.3	300.5	262.4	223.9	262.3	99.6	80.0	59.9	79.8	102.6	83.0	62.9	82.8
N_4	FYM (33%) + BGS ((50%)	308.0	271.9	230.8	270.2	305.3	267.2	232.1	268.2	101.3	84.4	64.6	83.4	103.3	86.4	66.6	85.4
N_5	FYM (50%) + BDF (50%)	299.3	264.7	216.0	260.0	296.7	260.0	217.3	258.0	98.0	78.2	58.6	78.3	101.0	81.2	61.6	81.3
N_6	Recommended package of practices (RPP)	310.6	274.5	233.4	272.8	307.9	269.8	234.7	270.8	104.9	89.4	65.1	86.5	106.9	91.4	66.4	88.2
N_7	Farmers' Practice	241.4	212.6	181.1	211.7	238.7	207.9	182.4	209.7	77.1	56.8	49.1	61.0	79.1	58.8	49.1	62.3
	Mean	295.5	260.7	218.9		293.3	256.2	220.2		97.0	78.4	59.5		99.4	80.8	61.6	
		S.Em±			CD @ 0.05	S.Em±		CD @ 0.05		S.Em±		CD @ 0.05		S.Em±		CD @ 0.05	
Cultivars (C)		8.45			33.18	8.50		33.39		4.47		17.56		2.80		10.98	
Nutrient management practices (NMP)		14.52			44.75	14.47		44.58		5.41		16.68		4.57		14.09	
Cultivars at same level of Nutrient management		23.18			69.08	21.08		60.90		13.17		32.64		9.69		24.23	
Cultivars at same or		23.95			69.22	22.33		64.09		12.19		30.98		9.37		23.11	

different level of Nutrient management								

FYM - Farm Yard Manure, VC – Vermicompost, BGS-Biogas slurry BDF- Biodigester filtrate C_1 - SNK 635 C_2 – CO 86032, C_3-Konanakatte, DAP- Days after Planting

Table 3: Cane diameter and Internodal length of Sugarcane as influenced by organic, integrated nutrient management practices and cultivars

Vertical strips [Nutrient management practice (NMP)]		Cane diameter (cm)								Internodal length (cm)							
		Plant Cane				Ratoon Cane				Plant Cane				Ratoon Cane			
		Horizontal strips (Cultivars)															
		C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
N_1	FYM (33%) + VC (33%) + BGS (33%)	2.89	2.83	2.74	2.82	2.83	2.77	2.64	2.74	10.56	10.48	8.63	9.89	10.46	10.38	8.93	9.99
N_2	FYM (33%) + VC (33%) + BDF (33%)	2.89	2.83	2.73	2.82	2.82	2.76	2.63	2.74	10.47	10.40	8.39	9.75	10.37	10.41	8.69	9.89
N_3	FYM (50%) + VC (50%	2.89	2.83	2.73	2.82	2.82	2.77	2.63	2.74	10.52	10.44	8.45	9.80	10.42	10.37	8.74	9.91
N_4	FYM (33%) + BGS ((50%)	2.90	2.84	2.75	2.83	2.84	2.78	2.64	2.75	10.70	10.62	8.77	10.03	10.60	10.40	9.03	10.08
N_5	FYM (50%) + BDF (50%)	2.88	2.82	2.72	2.80	2.81	2.75	2.62	2.73	10.45	10.38	8.26	9.70	10.43	10.32	8.55	9.83
N_6	Recommended package of practices (RPP)	2.91	2.86	2.75	2.84	2.84	2.79	2.65	2.76	10.41	10.32	8.51	9.75	10.31	10.46	9.04	10.00
N_7	Farmers' Practice	2.87	2.81	2.66	2.78	2.80	2.75	2.57	2.70	8.41	8.56	7.00	7.99	8.31	8.49	7.29	8.10
	Mean	2.89	2.83	2.73		2.82	2.77	2.64		10.22	10.17	8.29		10.13	10.12	8.61	
		S.Em±			CD @ 0.05	S.Em±		CD @ 0.05		S.Em±		CD @ 0.05		S.Em±		CD @ 0.05	
Cultivars (C)		0.12			NS	0.11		NS		0.40		1.57		0.35		1.37	
Nutrient management practices (NMP)		0.14			NS	0.15		NS		0.49		1.52		0.48		1.48	
Cultivars at same level of Nutrient management		0.21			NS	0.21		NS		1.05		2.73		0.82		2.13	
Cultivars at same or different level of Nutrient management		0.21			NS	0.22		NS		0.99		2.54		0.81		2.01	

FYM - Farm Yard Manure, VC – Vermicompost, BGS-Biogas slurry, BDF – Bio-digester filtrate, C_1 - SNK 635, C_2 – CO 86032, C_3-Konanakatte, DAP- Days After Planting

Table 4: Number of mill able canes and Single cane weight of sugarcane as influenced by organic, integrated nutrient management practices and cultivars

Vertical strips [Nutrient management practice (NMP)]		Number of mill able canes (000 ha^{-1})								Single cane weight (kg)							
		Plant Cane				Ratoon Cane				Plant Cane				Ratoon Cane			
		Horizontal strips (Cultivars)															
		C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
N_1	FYM (33%) + VC (33%) + BGS (33%)	97.0	78.5	58.3	77.9	95.3	76.5	57.7	76.5	1.44	1.37	1.16	1.32	1.34	1.31	1.08	1.24
N_2	FYM (33%) + VC (33%) + BDF (33%)	95.3	76.1	57.1	76.2	93.6	73.9	56.9	74.8	1.40	1.36	1.13	1.30	1.31	1.29	1.06	1.22
N_3	FYM (50%) + VC (50%	96.6	77.0	57.9	77.2	94.4	75.0	57.2	75.6	1.42	1.36	1.15	1.31	1.29	1.30	1.08	1.22
N_4	FYM (33%) + BGS ((50%)	98.3	81.4	62.6	80.8	98.6	79.9	62.3	80.3	1.45	1.38	1.21	1.35	1.36	1.32	1.15	1.28
N_5	FYM (50%) + BDF (50%)	95.0	75.2	56.6	75.6	91.7	73.2	55.4	73.4	1.38	1.33	1.13	1.28	1.28	1.27	0.99	1.18
N_6	Recommended package of practices (RPP)	101.9	86.4	63.1	83.8	99.9	84.1	62.8	82.2	1.44	1.40	1.20	1.35	1.35	1.33	1.17	1.28
N_7	Farmers' Practice	74.5	55.1	47.1	58.9	73.8	54.1	46.5	58.1	1.15	1.02	0.92	1.03	1.05	0.99	0.86	0.97
	Mean	94.1	75.7	57.5		92.5	73.8	57.0		1.38	1.32	1.13		1.28	1.26	1.06	
		S.Em±			CD @ 0.05	S.Em±		CD @ 0.05		S.Em±		CD @ 0.05		S.Em±		CD @ 0.05	
Cultivars (C)		4.21			16.54	2.94		11.54		0.05		0.20		0.04		0.17	
Nutrient management practices (NMP)		7.49			23.07	3.54		10.90		0.06		0.20		0.08		0.26	
Cultivars at same level of Nutrient management		15.93			35.12	11.64		29.10		0.12		0.28		0.12		0.26	

Cultivars at same or different level of Nutrient management	15.48	34.06	10.55	27.43	0.12	0.29	0.13	0.28

FYM - Farm Yard Manure, VC – Vermicompost, BGS-Biogas slurry, BDF – Bio-digester filtrate, C_1 - SNK 635, C_2 – CO 86032, C_3- Konanakatte

Table 5: Sugarcane Cane yield and Liquid Jaggery yield as influenced by organic, integrated nutrient management practices and cultivars

Vertical strips [Nutrient management practice (NMP)]		Cane yield (t ha^{-1})								Liquid Jaggery yield (t ha^{-1})							
		Plant Cane				Ratoon Cane				Plant Cane				Ratoon Cane			
		Horizontal strips (Cultivars)															
		C1	C2	C3	Mean	C1	C2	C3	Mean	C1	C2	C3	Mean	C1	C2	C3	Mean
N1	FYM (33%) + VC (33%) + BGS (33%)	132.92	106.15	72.99	104.02	122.08	102.57	67.66	91.35	18.27	14.27	9.65	14.06	16.61	14.06	8.85	13.17
N2	FYM (33%) + VC (33%) + BDF (33%)	127.09	101.87	69.10	99.35	116.09	101.94	63.83	87.22	17.29	13.89	9.02	13.40	15.66	13.80	8.18	12.55
N3	FYM (50%) + VC (50%	130.34	103.95	72.17	102.15	119.67	103.28	66.51	88.39	17.83	14.23	9.49	13.85	16.26	14.14	8.66	13.02
N4	FYM (33%) + BGS ((50%)	136.41	111.46	81.32	109.73	125.41	110.80	75.88	98.77	18.93	15.44	10.89	15.09	17.32	15.39	10.10	14.27
N5	FYM (50%) + BDF (50%)	125.12	100.23	69.23	98.20	113.83	99.56	63.90	84.66	17.00	13.65	8.99	13.21	15.38	13.56	8.19	12.37
N6	Recommended package of practices (RPP)	140.29	118.66	80.97	113.31	129.29	119.40	75.91	101.19	18.63	15.78	10.40	14.94	16.65	15.98	9.72	14.12
N7	Farmers' Practice	83.02	55.01	48.20	62.08	72.89	54.68	42.87	53.28	11.28	7.39	6.25	8.31	9.77	7.34	5.50	7.54
	Mean	125.03	99.62	70.57		114.18	98.89	65.22		17.03	13.52	9.24		15.38	13.47	8.46	
		S.Em±			CD @ 0.05	S.Em±		CD @ 0.05		S.Em±		CD @ 0.05		S.Em±		CD @ 0.05	
Cultivars (C)		4.99			19.60	3.05		11.98		0.54		2.12		0.52		2.03	
Nutrient management practices (NMP)		4.93			15.20	6.66		20.51		0.69		2.12		0.62		1.92	
Cultivars at same level of Nutrient management		8.91			23.17	8.25		22.28		1.48		4.05		1.79		4.65	
Cultivars at same or different level of Nutrient management		8.17			22.06	9.49		26.57		1.39		3.77		1.63		4.48	

FYM - Farm Yard Manure, VC – Vermicompost, BGS-Biogas slurry, BDF – Bio-digester filtrate, C_1 - SNK 635, C_2 – CO 86032, C_3- Konanakatte

Table 6: Liquid jaggery recovery % as influenced by organic, integrated nutrient management practices and cultivars

Vertical strips [Nutrient management practice (NMP)]		Liquid Jaggery Recovery (%)							
		Plant Cane				Ratoon			
		Horizontal strips (Cultivars)							
		C1	C2	C3	Mean	C1	C2	C3	Mean
N1	FYM (33%) + VC (33%) + BGS (33%)	13.75	13.44	13.23	13.47	13.58	13.68	13.06	13.44
N2	FYM (33%) + VC (33%) + BDF (33%)	13.61	13.63	13.05	13.43	13.48	13.53	12.85	13.29
N3	FYM (50%) + VC (50%	13.68	13.68	13.16	13.51	13.58	13.68	13.03	13.43
N4	FYM (33%) + BGS ((50%)	13.88	13.83	13.39	13.70	13.78	13.83	13.29	13.63
N5	FYM (50%) + BDF (50%)	13.59	13.63	13.02	13.41	13.49	13.63	12.81	13.31
N6	Recommended package of practices (RPP)	13.26	13.31	12.82	13.13	12.83	13.38	12.76	12.99
N7	Farmers' Practice	13.54	13.45	12.98	13.32	13.37	13.41	12.81	13.20
	Mean	13.62	13.57	13.09		13.45	13.59	12.94	
		S.Em±		CD @ 0.05		S.Em±		CD @ 0.05	
Cultivars (C)		0.56		NS		0.65		NS	
Nutrient management practices (NMP)		0.64		NS		0.65		NS	
Cultivars at same level of Nutrient management		0.89		NS		0.99		NS	
Cultivars at same or different level of Nutrient management		0.88		NS		0.92		NS	

FYM - Farm Yard Manure, VC – Vermicompost, BGS-Biogas slurry, BDF – Bio-digester filtrate, C_1 - SNK 635, C_2 – CO 86032, C_3- Konanakatte

Conclusion

The sugarcane cultivar SNK 635 recorded significantly higher cane yield than Co 86032 and Konanakatte cultivar. The Liquid jaggery yield was also higher with SNK 635 cultivar than Co 86032 and Konanakatte cultivar. Among organic nutrient management practices, 100% organic equivalent to recommended dose of nitrogen (RDN) through farm yard manure (FYM) (50%) + Biogas slurry (BGS) (50%), FYM (33%) + Vermicompost (VC) (33%) + Biogas slurry (33%), FYM (50%) + VC (50%), FYM (33%) + Vermicompost

(33%) + Bio-digester filtrate (BDF) (33%) and FYM (50%) + Bio-digester filtrate (50%) recorded higher cane and liquid jaggery yield, found to be on par with each other. Organic nutrient management practices recorded cane and liquid jaggery yield was found on par with RPP treatment. Cultivar SNK 635 with RPP treatment recorded significantly higher cane and liquid jaggery yield and found on par with SNK 635 and Co-86032 cultivar of all organic treatments among interactions.

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