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CONTENTS **Page**

IMPROVED DESIGN OF A FALLING-FILM TUBULAR EVAPORATOR WITH A MAINTENANCE-FRIENDLY NOVEL JUICE DISTRIBUTOR

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Several variants of falling-film tubular evaporators (FFTE) are in use in the sugarcane industry. Most of these suffer from three main draw backs: (i) occasional tube chokes due to uneven distribution of juice, (ii) absence of headroom between the top tube sheet and juice distributor necessitating its dismantling for mechanical de-scaling of tubes, and (iii) occasional cracking of austenitic SS tubes fitted in carbon steel calandria caused by thermal stresses due to widely dissimilar expansion at elevated temperature. A new design of juice distributor has been developed. It comprises an inlet weir box and a five-stage cascading system that forms a uniform shower of juice across the entire cross-section. It is installed at 2 m above the top tube sheet to facilitate easy access to various tubes for inspection or mechanical de-scaling without its dismantling. A segmented tray plate bolted to the top tube sheet and having an individual tripod-type umbrella structure located over each tube ensures equal wetting of each and every tube, making the system failsafe. One 3300 m2 FFTE unit with this design of distributor is installed at a sugar factory in India. It has successfully completed three harvesting seasons without any tube choke. This plant produces plantation-white sugar by the double sulphitation process and has to carry out mechanical de-scaling during the crop to maintain heat transfer efficiency. Thermal stress analysis of another FFTE unit has been carried out using advanced software to simulate stress, buckling and deflection behaviour at elevated temperature for combination of carbon steel calandria and different grades of SS tubes to develop a structurally strong design with enhanced operational reliability. FFTEs with SS439 material tubes are installed as 2nd-4th effect evaporators at a 24,000 tcd sugar plant of the White Nile Sugar Company, Sudan. In the first crop, there was a problem of tube chocking due to intermittent supply of juice arising out of frequent stoppage of milling process. In subsequent crops, the supply of juice to the evaporator station has been largely consistent and, hence, the problem of tube chocking was not experienced. This plant has completed three more crushing seasons without any tube failure or structural deformity.

Key words: Falling-film tubular evaporator, cascade juice distributor, tripod umbrella, thermal-stress analysis

INTRODUCTION

The Indian sugar industry largely produces plantation-white sugar by double sulphitation (DS) process, although a couple of factories produce refined sugar by the defeco-remelt-phospho-flotation (DRP) process. All the falling-film evaporators operating in the Indian sugar industry are of a tubular type and comprise carbon steel calandria fitted with 10 m long SS 304 tubes. Several variants of juice distributors are in use, but most of these are of integral design, such that these are required to be located just above the top tube sheet as mentioned by Rein (2007). Therefore, one must dismantle the distributor for mechanical de-scaling of tubes, making the whole process very cumbersome, time-consuming and impractical to adopt during the crushing season. These falling-film tubular evaporators (FFTE) were initially used as 1st or 2nd effect vessels where the scale, predominantly calcium phosphate and calcium sulphite, is softer and largely removable by chemical cleaning (CIP). In 2007, Shree Renuka Sugars' Athani unit in Karnataka (India) installed an IPRO design quintuple-effect evaporator set having all the five vessels of the falling-film tubular type fitted with 12 m long SS 304 tubes. This plant produces white sugar by the DRP process and they are reported to be working well. In 2011, India Cane and Power's sugar plant in Karnataka (India) installed a BMA design quintuple-effect evaporator set having all the five vessels of the falling-film tubular type fitted with 10 m long SS304 tubes. This plant produces white sugar by the double sulphitation process and these FFTE units work well, except for the difficulty experienced in removing the scale by CIP during the crushing season from the 4th and 5th effect vessels as reported by Lehnberger et al. (2013). Many of the sulphitation factories face severe fouling problems in the later effects where the scale, predominantly silicates and calcium sulphate, is very hard and is difficult to remove by CIP. Almost all sugarcane-processing factories, producing raw or white sugar, have to carry out mechanical de-scaling of evaporator tubes during the off-harvest, while the factories using the DS process often require mechanical de-scaling during the harvesting season. Mechanical de-scaling is carried out either by using a tool head cutter or a hydro-jet system. In both of these systems, workmen are required to enter the space above the top tube sheet for holding the flexible shaft or the hydro-jet lance and guiding it inside the tubes one by one for mechanical de-scaling. The earlier practice of using tool head cutter is labour intensive and also reduces the life of the tubes. It is being gradually replaced by hydro jet de-scaling system that is much more efficient. However, both systems require sufficient head room and leg space for ease of maneuvering the device. Hence, there has been an urgent need for redesigning the juice distributor to ensure uniform wetting of each and every tube and to provide sufficient head and leg room over the top tube sheet for ease of maintenance without its dismantling. Isgec Heavy Engineering Ltd, India has developed and supplied an improved design of FFTE, fitted with a novel juice distributor, that is reliable and maintenance friendly. The vessel design has been improved by thermal stress analysis and incorporation of ferritic (SS439) tubes instead of austenitic (SS304) tubes. This paper describes the salient features and advantages of the juice distributor and results of the FEA study for a 3500 m2 FFTE unit.

Features of the novel juice distributor

The novel juice distributor is comprised of two main components (Fig. 1). The first component, called the cascade juice distributor, consists of an inlet weir box and a 5-stage cascading system that forms a uniform shower of juice across the entire cross section of the vessel. The second component, called the segmented tray plate, consists of individual tripod umbrellas located over each tube and welded to a tray plate. This tray plate is segmented and bolted to top tube sheet for ease of dismantling (Fig. 1). For better understanding, an exploded view of tripod umbrellas is shown in Figure 2. These prevent short circuiting and also ensure equal and uniform wetting of each and every tube. The cascade distributor is installed 2 m above the top tube sheet to facilitate easy access to various tubes for inspection or mechanical de-scaling without its dismantling (Fig. 3). Each segment of the tray plate, along with the tripod umbrellas, can be removed and placed along the wall to allow easy access to the tubes during the crushing or after crushing. The novel juice distributor is simple, yet rugged and reliable. It also ensures uniform wetting of each and every tube of the FFTE. However, the vessel height is increased by about 1.5 m. The cascade juice distributor, once assembled inside the vessel, need not be dismantled even during the off-crush. The 3300 m2 FFTE vessel fitted with this distributor, installed at our sister sugar factory in India, has successfully completed three processing seasons without any tube choke. This plant produces plantation-white sugar by the double sulphitation process and is required to carry out mechanical de-scaling after every two cycles of chemical cleaning (CIP) during the crop to maintain heat transfer efficiency. The design wetting rate of this vessel is 20-22 L/(cm h).

Tube de-scaling system

Scaling on the surface of tubes of FFTE occurs overtime, as ingredients of the juice, mainly inorganic materials, become saturated and precipitate, some of which attach to the tube surface causing scaling. It is a normal phenomenon during sugarcane processing, eventually reaching a stage when the evaporation rate drops below acceptable levels. This requires time for shut down of the fouled vessel for tube cleaning. The scale can be removed either by chemical cleaning (CIP) and/or mechanical de-scaling process. However, in a situations when the quality of juice is bad, chemical cleaning does not remove the scale completely, particularly in factories using the DS process. The remaining scale is then removed by tool head cutter to restore the original condition of the tubes. Srivastava and Goel (2014) have described the advantages of the hydro-jet de-scaling process, comprising a skid-mounted high-pressure water-pumping system, a lance tube and a mixed flow rotating head type nozzle to dislodge the scale from the surface of the tube. The pump, sourced from Gardner Denver System, USA, operated at 1000 bar pressure. This has been successfully used for de-scaling of 10 m long tubes of FFTE in many sugar factories in India and Sudan. There is no need to carry out any caustic soda boiling prior to hydro-jetting. The quality of surface finish is far better than by tool head cutting. Figure 4 shows hydro jet tube cleaning in progress at one of the project sites.

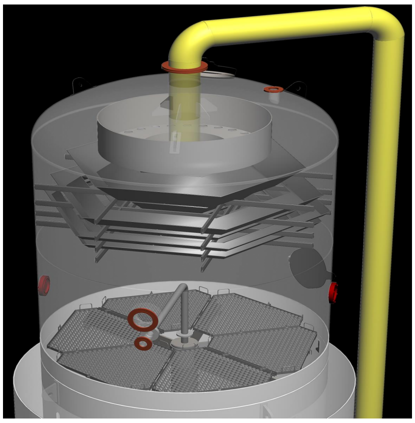

Fig. 1. Internal 3D view of the novel juice distributor.

Fig. 2. Exploded view of tripod umbrellas fitted on the tray plate.

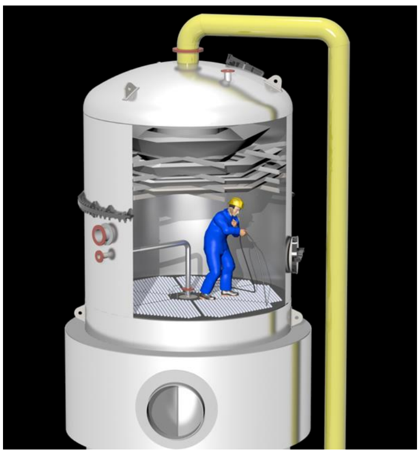

Fig. 3. Mechanical cleaning of tubes in progress.

Fig. 4. Hydro-jet cleaning of tubes in progress.

Generally, falling-film tubular evaporators (FFTE) are comprised of carbon steel calandria with tubes of 35-45 mm diameter and 10-12 m long made of SS 304, an austenitic stainless steel. However, the coefficient of linear expansion of SS 304 is 1.43 times that of carbon steel, resulting in higher thermal stresses at elevated temperatures, particularly in evaporators operating at temperatures above 100°C. The sugar industry wants material for tubes that has nearly same coefficient of linear expansion as that of carbon steel. After detailed study we selected SS 439, a ferritic stainless steel that has a coefficient of linear expansion 0.87 times that of carbon steel. Kaul et al. (2015) described the advantages of SS 439 tubes due to their superior yield strength, higher thermal conductivity and better resistance to stress corrosion as compared to SS 304 tubes. Table 1 compares the mechanical and thermal properties of SS 439 tubes, SS 304 tubes and carbon steel shell/ tube sheets.

Table 1. Properties of SS 439 tubes, SS 304 tubes and carbon steel calandria.

Parameter	Unit	SS 439 tubes	SS 304 tubes	Carbon steel shell/tube sheet
Fabrication procedure		Laser welded	Electric-resistance welded (ERW)	Arc welded
Type of steel		Ferritic	Austenitic	Ferritic
Density	kg/dm^3	7.75	7.75	7.85
Ultimate tensile strength	MPa	450	586	410
0.2% (Yield strength)	MPa	370	350	250
% Elongation	%	45	60	23
Coefficient of linear expansion	μ/m/K	9.8	16.1	11.3
Young's modulus	MPa	193,000	193,000	206,000
Thermal conductivity	W/m/°C	24	16	39
Poisson ratio		0.31	0.31	0.29
Stress corrosion resistance	Range 0-100	100	20	100

Kharbanda *et al.* (2015) studied the design optimization of sugar plant equipment including tubular juice heaters and vacuum pans using advanced Finite Element Analysis (FEA) software. We have extended this to optimize the design of FFTE assembly made of carbon steel calandria fitted with stainless steel tubes of two different grades, i.e. SS 439 and SS 304. Since the first effect of evaporator set is subjected to the highest thermal and pressure loading, we chose its operating parameters for the thermal stress analysis. Solid works software version 2016 and ANSYS Workbench R15 software wereused for the 3D modeling and thermal stress analysis, respectively. The 3500 m2 FFTE fitted with integral entrainment separator, novel juice distributor and 45 mm diameter, 10 m long tubes was selected as a complete assembly for FEA. A 3D model of the assembly is shown in Figure 5. The assembly is constrained (fixed) at bottom support skirt. The pressure and temperature were applied simultaneously in full body. Three iterations were done, i.e. (1) FFTE assembly at the time of hydro test, (2) FFTE assembly fitted with SS 304 tubes and subjected to operating parameters below, and (3) FFTE assembly fitted with SS 439 tubes and subjected to operating parameters below:

- Tube side pressure and temperature 1.2 bar (g) and 115°C
- Shell side pressure and temperature 1.8 bar (g) and 130°C
- Ambient temperature 30°C
- Material of construction and their properties As in Table 1.

Fig. 5. 3D model of the FFTE.

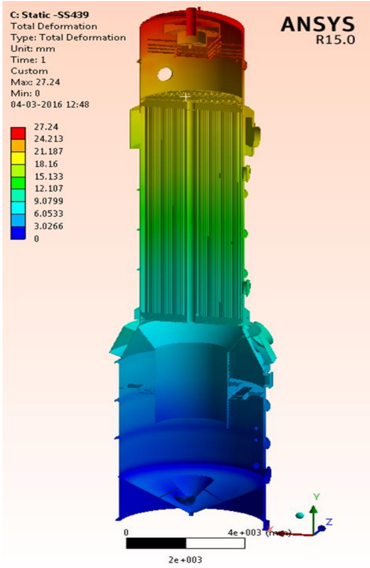

Fig. 6. Deflection pattern of the assembly.

Results of the FEA study

A FEA study was carried out based on above inputs. Figure 6 shows the deflection pattern of the FFTE assembly at the operating parameters. Other important outputs, such as stress pattern in the top tube sheets and stress/deflection pattern in the tubes, are discussed below. Stress in tube sheets: The von Mises stress patterns for the top tube sheets in respect of three different loading scenarios are shown in Figures 7-9.

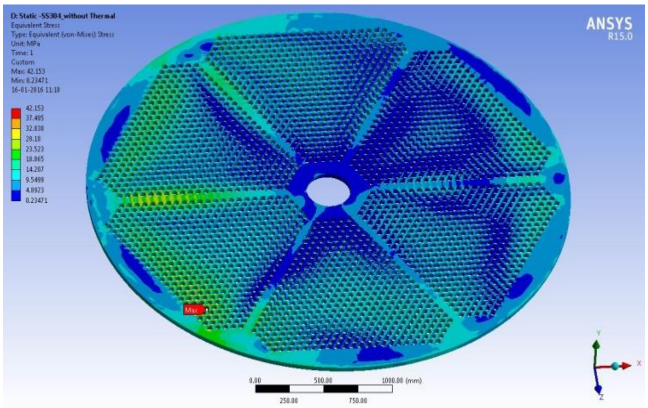

Fig. 7. Stress pattern in top tube sheet in cold conditions i.e. at hydrotest.

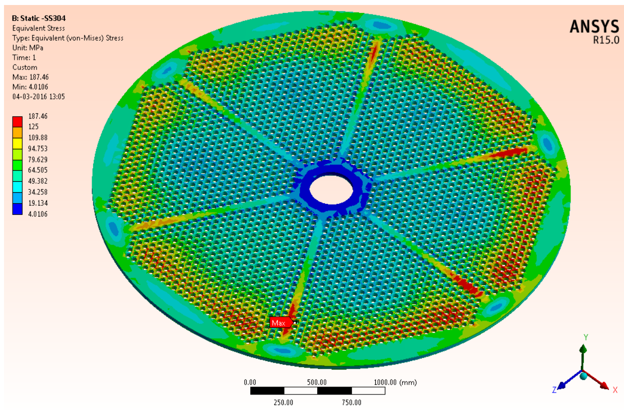

Fig. 8. Stress pattern in top tube Sheet with SS 304 tubes in hot conditions.

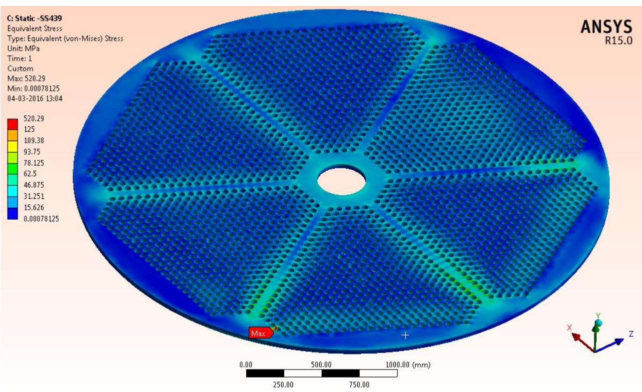

Fig. 9. Stress pattern in top tube Sheet with SS 439 tubes in hot conditions.

It can be observed from above figures that at hydro-test condition, the stress in the top tube sheet is only 35-40 Mpa. However, once the FFTE vessel is subjected to the operating temperature conditions, the stress level in the tube sheets increases substantially due to the difference in the coefficient of linear expansion between the calandria and the tubes. At the operating pressure and temperature conditions, the top tube sheet (assembled with SS 304 tubes) develops a stress level of 130-150 MPa, which decreases to100-120 MPa for tube sheet (assembled with SS 439 tubes).

Deflection pattern in the tube bundle: Figures 10 and 11 show the deflection pattern of the tube bundle at operating pressure and temperature for SS 304 and SS 439 tubes, respectively. It is clear from Figure 10 that, for the SS 304 tube bundle, all the tubes have buckled-in to cater the relatively lower expansion of carbon steel calandria shell. However, for the SS 439 tube bundle, the tube sheets have sagged inwards marginally and the outer periphery tubes have followed the shell expansion (Fig. 11). Stress in tubes: At the hydro-test condition, the stress in the tubes is only 6-12 MPa. At the operating conditions, SS 304 tubes develop a stress of 65-130 MPa, which decreases to 30-50 MPa if the tubes are SS 439. A summary of stress values for tube sheets and SS tubes is given in Table 2.

Table 2. Summary of actual stress values in top tube sheet and SS tubes.

Description	Unit	Iteration-1 Hydro test	Iteration-2 SS 304 tubes	Iteration-3 SS 439 tubes
Actual stress value in top tube sheet	MPa	35-40	130-150	100-120
Actual stress value in SS tubes	MPa	6-12	65-130	30-50

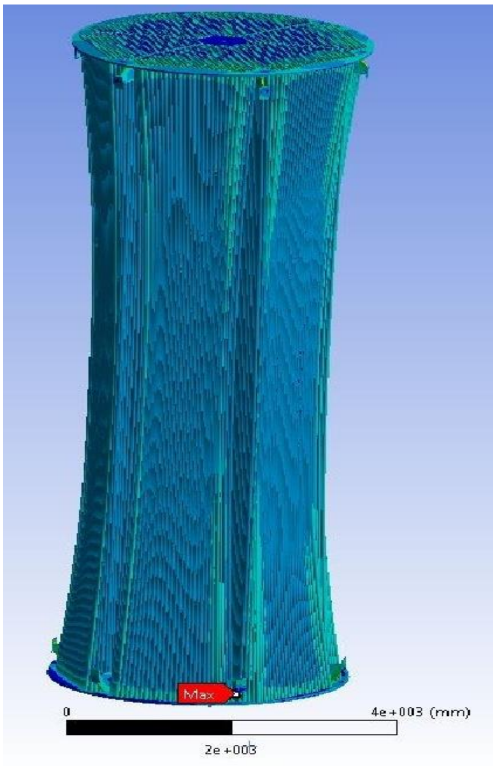

Fig. 10. Deflection pattern of SS 304 tubes.

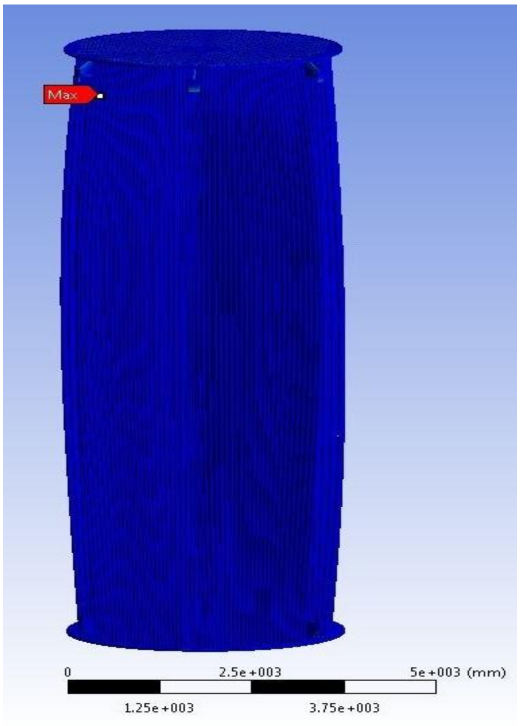

Fig. 11. Deflection pattern of SS 439 tubes.

CONCLUSIONS

The novel juice distributor ensures uniform wetting of each and every tube of the FFTE assembly and also facilitates mechanical de-scaling by a tool head cutter or the hydro-jet system. The cascade juice distributor, once assembled inside the FFTE vessel, need not be disturbed or dismantled even during the off-crush. A 3300 m2 FFTE vessel fitted with this juice distributor, installed at our sister sugar factory in India, has successfully completed three crushing seasons without any tube choke. The tubes, as well as the tube sheets of FFTE unit fitted with SS439 tubes, are subjected to much lower stresses at the operating conditions, thereby improving their life and reliability compared to a FFTE unit fitted with SS 304 tubes. FFTEs with SS439 tubes installed as 2nd to 4th effect evaporators at a 24,000 tcd sugar plant in Sudan have completed four processing seasons without any tube failure or structural deformity.

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INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT ON THE GROWTH, YIELD AND SUGAR CONTENT OF TROPICAL SUGARBEET (*Beta vulgaris* L.)

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ABSTRACT

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during November 2016 to April 2017 to find out the influence of integrated nutrient management on the growth, yield and sugar content of tropical sugarbeet. The experiment comprised two tropical sugarbeet varieties viz.PAC-60008 and SV-887and nine nutrient managements viz. Cowdung @ 10 t ha^{-1}, Poultry manure @ 5 t ha^{-1}, Recommended dose of chemical fertilizer (NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}), 75% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}, 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}, 50% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}, 50% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}, 75% NPK and other inorganic fertilizers + cowdung @ 5 t ha^{-1} and 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}.The experiment was laid out in a randomized complete block design with three replications. The tallest plant (57.25 cm, at 100 DAS) was recorded in PAC-60008 fertilized with NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1} while the highest number of leaves plant^{-1}(36.83, at 100DAS) was found in SV-887 with 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}and the highest SPAD value (87.20, at 80 DAS) was recorded in SV-887 fertilized with 75% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}. The highest top length (50.33 cm) and top yield (38.67 t ha^{-1}) at harvest were recorded in SV-887 fertilized with NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}and PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}, respectively. The highest beet girth (38.58 cm), average beet weight (0.98 kg) and beet yield (98.18 t ha^{-1}) were recorded in PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @5 t ha^{-1}. The highest values of beet girth, average beet weight and beet yield were at par in PAC-60008 fertilized with NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}and PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}while the lowest beet yield (22.10 t ha^{-1}) was recorded in SV-887 fertilized with cowdung @ 10 t ha^{-1}. The highest brix (18 %) was recorded at harvest (150 DAS) in PAC-60008 fertilized with 50% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}while the lowest brix (14.67%) was obtained in SV-887 with poultry manure @ 5 t ha^{-1}, and 75% NPK and other inorganic fertilizers + cowdung @ 5 t ha^{-1}. Therefore, variety PAC-60008 fertilized with 75% recommended dose of NPK and other inorganic fertilizers + poultry manure @ 2.5 appears as the promising combination in terms of beet yield.

Key words: Sugarbee**t,** nutrient management, growth, yield, sugar content

INTRODUCTION

Sugarbeet (*Beta vulgaris*L.), is a temperate crop and its root contains high concentration of sucrose. Sugarbeet is the second most important sugar crop next to sugarcane that covers 30-40 % world sugar. Recently, some tropical sugarbeet varieties have been developed which can be grown in tropical and subtropical regions of the world. The current production of sugar in Bangladesh is meeting about 5% of total demand and 20% of total requirement covers with jaggery mainly from sugarcane and rest 75% sugar demand is fulfilled by importation (Rahman *et al*., 2016). The main causes of lower sugar production include less supply of sugarcane in the factories and very poor sugar recovery. In Bangladesh, due to acute shortage of sugarcane as raw materials most of the sugar mills remain inoperative for longer period of time in every year. The area under cane cultivation is drastically reduced due to pressure of cereals and other short-duration crops, which cause lower amount of sugarcane production. Sugarbeet has got many benefits compared to sugarcane due to short duration with high sucrose contents. In this regard sugarbeet might be an excellent alternative to sugarcane in Bangladesh by enhancing processing facilities in the existing sugar mills. The Government of Bangladesh is emphasizing the attainment of self-sufficiency in sugar and jaggery production by introducing sugarbeet in the country and boosting up the sugarcane production. Feasibility of sugarbeet cultivation in Bangladesh is under trial although some people are growing low sucrose containing genotype as salad and vegetable purposes. Agronomic practices such as variety, spacing and fertilizer management are important for appreciable root yield and quality of tropical sugarbeet (Paul *et al*., 2018). Soil health condition in Bangladesh has been drastically deteriorated in the last couple of decades, in inverse relation with the target of producing more crops from a small amount of land. Nitrogen fertilization can improve leaf area, photosynthetic rate and eventually high yield (Cai and Ge, 2004). Phosphorus is the second most important nutrient for sugar beet production. Phosphorus plays an important role in energy transfer within the plants and structural integrity of cell membrane. Application of 120 kg P_2O_5 and 100 kg N ha^{-1} resulted in higher beet and sugar yield (Khan, 2003). Although enhanced dosage of sole N fertilizer increases growth and yield of sugar crops, it raises the sugar losses to molasses and ultimately lower sugar recovery (Salami and Saadat, 2013). Balanced crop nutrition could enhance crop and sugar yields significantly (30–60%) as 1 kg of macronutrients produces about 114 kg of stripped sugarcane (Soomro *et al.,* 2014). A crop having yield of 100 tons per hectare uptakes 207 kg N, 30 kg P_2O_5 and 233 kg K_2O from the soil (Jagtap *et al*., 2006). Manure is also important for sugarbeet yield because of containing all macro and micro nutrients required for plant growth but in small amount. Farm yard manure increased the sugar yield by 10% when applied at the rate of 20 t ha^{-1} compared to control plots (Javaheri*et al.*, 2005). Hergert and Nielsen (2011) reported that of manure increased sugar yield significantly with no significant effect on sugar loss to molasses. So, manure could be a valuable source of nutrients for sugarbeet because it mineralizes slowly which can affect sugar content and impurities. Topcuoğlu and Önal (2005) reported that application of poultry manure @ 10 t ha^{-1} increased yields and sugar content of sugarbeet. There is no denying the need of using chemical fertilizers and adopting multiple cropping to meet the growing demand of food, but the farmers should at the same time be encouraged to use more organic fertilizer along with the chemical ones to recover the soil health. Now-a-day, attention has been directed towards organic manure because of the rising cost of inorganic fertilizers coupled with their inability to give the soil the desired sound health. Combined application of manure with inorganic fertilizers increased yield and quality of various crops were reported elsewhere (Oyedeji*et al*., 2014; Pal *et al*., 2016; Ahmad *et al*., 2016). Cowdung and poultry manure are the excellent soil amendment that provides nutrients for growing crops and also improves soil health when applied wisely because of organic matter content combined with available nutrients for plant growth and development. In Bangladesh no systematic research work in this area has so far been done particularly in sugarbeet cultivation. As a promising sugar crop in Bangladesh, the feasibility study of sugarbeet varieties under various nutrient management are needed to be studied. Therefore, the present study was undertaken with a view to delineating the performance of sugarbeet varieties with variable nutrient management practices.

MATERIALS AND METHODS

Experimental sites and experimentation

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during November 2016 to April 2017. The experimental field is located at $24^0 75'$N latitude and $90^0 50'$E longitude at an altitude of 18 m. The field belonging to the Sonatala series of Old Brahmaputra Floodplain Agro ecological Zone (AEZ-9) was a medium high land with well drained silt loam texture and non-calcareous dark grey floodplain soils having pH 6.5 and low in organic matter (1.67 %) content (UNDP and FAO, 1988). The experiment comprised two tropical sugarbeet varieties viz. PAC-60008 (V_1) and SV-887 (V_2) and nine nutrient management viz. Cowdung @ 10 t ha^{-1} (F_1), Poultry manure @ 5 t ha^{-1} (F_2), Recommended dose of chemical fertilizer (NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}) (F_3), 75% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1} (F_4), 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1} (F_5), 50% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1} (F_6), and 50% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1} (F_7), 75% NPK and other inorganic fertilizers + cowdung @ 5 t ha-1 (F_8), 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha-1 (F_9). The experiment was laid out in a randomized complete block design with 3 replications. The size of each unit plot was 2.5 m × 2.0 m. The distances between two adjacent plots were 0.5 m and that between two blocks was 1m. At the time of final land preparation, respective unit plots were fertilized with different levels of cow dung and poultry manure according to treatments. The manures were thoroughly mixed with the soil. Nitrogen, phosphorus, potassium, sulphur, zinc and boron were applied in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Whole amount of triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid were applied at final land preparation as specified in the treatments. Urea was applied in three equal splits at 30, 50 and 70 days after sowing (DAS). Seeds were sown in rows on the ridge with 50 cm × 20 cm spacing @ two seeds hill^{-1}on 30 November 2016. Thinning was done at 35 DAS leaving one healthy plant hill^{-1}. Gap filling was also done at 30 DAS from the out strips extra seedlings of the same age to have optimum population. Three hand weedings were done at 15, 30, 45 and 60 DAS. The crop was irrigated four times at 45, 70, 95 and 120 DAS. Earthing up was done at 60 DAS to facilitate soil moisture to the root for its maximum growth. The fungicide named “Score” was sprayed @ 3ml L^{-1} of water by hand sprayer. The insect pests (Sugarbeet caterpillar, red beetle) were controlled by spraying Nitro-505EC @ 2 ml L^{-1} (5 L ha^{-1}).

Plant height and leaf number plant^{-1}

Five plants were randomly selected immediately after emergence and marked with bamboo sticks in each plot excluding border rows to record the data on plant height and number of leaves plant^{-1}at 20-day intervals beginning 40 up to 100 DAS.

Measurement of leaf chlorophyll content

Chlorophyll meter values (SPAD) were recorded using a portable SPAD meter (Model SPAD-502, Minolta crop, Ramsey, NJ) at 20-day intervals, beginning 40 DAS upto 100 DAS. The instrument measures transmission of red light at 650 nm, at which chlorophyll absorbs light, and transmission of infrared light at 940 nm, at which no absorption occurs. The chlorophyll meter readings have been found to be positively correlated with destructive chlorophyll measurements in many crop species (Zhu *et al*., 2012) and considered as a useful indicator of the need of N top dressing during the crop growth. On the basis of these two transmission values, the instrument calculates a SPAD value that is well correlated with chlorophyll content (Paul *et al*., 2018).

Brix (%) measurement

Percent brix were measured by hand refractometer (ATAGO, Japan) at maturity stage beginning from 120 DAS at 15-day intervals up to 150 DAS (at harvest). Five beets of each plot were randomly collected. A sharp knife was used to remove the outer skin of sugarbeet root and sliced into small pieces as well as to extract a drop of juice by using mortar and pestle. Then the juice was transferred into the prism of the refractometer and also closed the day light plate to get the accurate measurement of brix (%) observed by eyepiece and then averaged to get mean data plot^{-1}.

Yield components and yield

After harvesting, plants were washed and cleaned by removing dead and dried leaves and soil adhering to beets. Data on plant characters and yield components were recorded from ten randomly selected plants from each plot. Beet yield was recorded from the whole plot harvest and converted to t ha^{-1}.

Statistical Analysis

All the recorded data were analyzed using analysis of variance (ANOVA) using a computer package MSTAT-C program. The treatment mean differences were adjudged by Duncan's Multiple Range Test (DMRT) Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Plant height

Plant height was significantly influenced by the interaction between sugarbeet variety and integrated nutrient management at 40 and 100 DAS (Table 1). The plant height progressively increased over time attaining the highest at final sampling date (100 DAS).At 40 DAS, the tallest plant (23.00 cm) was recorded in V_1× F_5 (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}) that was at par with V_1 x F_6 (PAC-60008 fertilized with 50% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}), V_1 x F_7 (PAC-60008 fertilized with 50% NPK and other inorganic fertilizers + poultry manure @ 5 t ha-1), V_1 x F_2(PAC-60008 fertilized with Poultry manure @ 5 t ha-1),V_2 x F_5 (SV-887 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha-1) and the lowest plant (19.00 cm) was recorded in V_2 x F_7 (SV-887 fertilized with 50% NPK and other inorganic fertilizers + poultry manure @ 5 t ha-1) while at 100 DAS the tallest plant (57.25 cm) was obtained in V_1× F_3 (PAC-60008 fertilized with NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}) which was at par with V_2× F_5(SV-887 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}),V_2× F_8(SV-887 fertilized with 75% NPK and other inorganic fertilizers + cowdung @ 5 t ha^{-1}), V_1× F_9 (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}),V_2 x F_6 (SV-887 fertilized with 50% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}),V_2 x F_3 (SV-887 fertilized with NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}), V_2x F_4(SV-887 fertilized with 75% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}), V_1 x F_4 (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1} and the shortest plant (40.67 cm) was found in V_1× F_1 (PAC-60008 fertilized with cowdung @ 10 t ha^{-1}) (Table 1). Genotypic characteristics with higher dose of nutrient might be responsible higher plant height in sugarbeet.

Leaf number

Number of leaves plant^{-1} with the interaction of variety and integrated nutrient management showed substantial differences over time. Table 2 shows that the leaf production plant^{-1}gradually increased in course of time and reached maximum at 100 DAS. The highest number of leaves plant^{-1}(36.83) was recorded in V_2× F_5 (SV-887 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}) which was at par with V_2× F_8 (SV-887 fertilized with 75% NPK and other inorganic fertilizers + cowdung @ 5 t ha^{-1}) and the lowest number of leaves plant^{-1}(24.17) was found in V_1 × F_2(PAC-60008 fertilized with poultry manure @ 5 t ha^{-1}.

SPAD value

The SPAD value or chlorophyll meter values of sugarbeet are illustrated in Table 3. SPAD value of sugarbeet was significantly influenced by the interaction between variety and integrated nutrient manage-ment at all dates of sampling. The SPAD value showed an increasing trend and reached maximum at 80 DAS and thereafter declined irrespec-tive of treatment differences. Similar trend of SPAD value of various crops was reported elsewhere (Tajul*et al*., 2013; Islam *et al*., 2014; Paul *et al*., 2018). The highest SPAD values of 40 and 60 DAS (40.30 and 66.33, respectively) were recorded in $V_2 \times F_5$ (SV-887 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}) while at 80 and 100 DAS (87.20 and 51.87 respectively), the highest SPAD values were found in $V_2 \times F_4$ (SV-887 fertilized with 75% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}) and $V_2 \times F_3$ (SV-887 fertilized with NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}), and the lowest SPAD values of 40 and 60 DAS (28.47 and 37.63 respectively) were recorded in V_1 x F_5(PAC-60008 fertilized 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}) and V_1 x F_1(PAC-60008 fertilized with cowdung @ 10 t ha^{-1}) while at 80 and 100 DAS (43.93 and 37.90 respectively), the lowest SPAD values were found in and V_1 x F_1(PAC-60008 fertilized with Cowdung @ 10 t ha^{-1}) and V_1 x F_7(PAC-60008 fertilized with 50% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}), respectively (Table 3).

Top length and top yield

The highest top length (50.33 cm) at harvest were recorded in $V_2 \times F_3$ (SV-887 fertilized with NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}) while the lowest one (30.00 cm) was recorded in $V_1 \times F_2$ (PAC-60008 fertilized with poultry manure 5 @ t ha^{-1}). The highest beet top yield (38.67t ha^{-1}) was found in $V_1 \times F_9$ (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}),which was statistically identical with $V_2 \times F_3$ (SV-887 fertilized with NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}) while the lowest one (20.00 t ha^{-1}) was recorded in $V_1 \times F_1$ (PAC-60008 fertilized with cowdung @ 10 t ha^{-1}). Combined application of inorganic fertilizer with manure increased beet top yield compared to sole application of manure as well as inorganic fertilizer was reported by Balakrishnan and Selvakumar (2008).

Yield components and beet yield

Root length was not significantly affected due to interaction effect of variety and integrated nutrient management. Table 4 shows that root length ranged 21.67 cm to 27.00 cm. Numerically the longest root (27.00 cm) was produced in $V_1 \times F_5$ (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}) and $V_1 \times F_9$ (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}) while the shortest (21.67 cm) one was produced in $V_2\times F_2$ (SV-887 fertilized with poultry manure @ 5 t ha^{-1}). The highest beet girth (38.58 cm), average beet weight (0.98 kg) and beet yield (98.18 t ha^{-1}) were recorded in $V_1 \times F_5$ (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}),which were at par with $V_1 \times F_3$ (PAC-60008 fertilized with NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}) and $V_1 \times F_9$ (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}). The lowest beet girth (29.30 cm) was recorded in $V_1 \times F_1$ (PAC-60008 fertilized with cowdung @ 10 t ha^{-1}) while the lowest average beet weight (0.220 kg) and beet yield (22.10 t ha^{-1}) were obtained in $V_2 \times F_1$ (SV-887 fertilized with cowdung @ 10 t ha^{-1}). The longest root, highest beet girth and average beet weight plant^{-1} contributed to the highest sugarbeet yield. Integrated nutrient management significantly influenced the yield components and root yield of sugarbeet. Balakrishnan and Selvakumar (2008) reported that 100% inorganic fertilizer through urea along with manure significantly increased beet yield which was comparable to 50% inorganic fertilizer along with manure.

Brix (%)

Sugarbeet brix (%) was significant due to interaction between variety and nutrient management at all sampling dates. Table 5 shows that in course of time percent brix increased up to 135 DAS irrespective of treatment combination while in some cases it was decreased. Similar decreasing trend of brix (%) was reported by Paul *et al.* (2018). At 120 DAS, the highest brix (15.33%) was recorded in $V_1 \times F_9$ (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}) which was at par with V_1 x F_4 (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + cowdung @ 10 t $ha^{-1}$and the lowest one (12%)was obtained in $V_2 \times F_3$ (SV-887 fertilized with NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}),which was similar to $V_2 \times F_6$(SV-887 fertilized with 50% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}). Table 5 indicates that at 135 DAS, the highest brix (17.67%) was recorded in $V_1 \times F_6$ (PAC-60008 fertilized with 50% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}) and $V_2 \times F_2$ (SV-887 fertilized with poultry manure @ 5 t ha^{-1}), which was at par with $V_1 \times F_9$ (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}), V_1 x F_4 (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + cowdung @ 10 t ha-1), $V_1 \times F_8$ (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + cowdung @ 5 t ha^{-1}), $V_2 \times F_5$(SV-887 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}), $V_1 \times F_2$ (PAC-60008 fertilized with poultry manure @ 5 t ha^{-1}), $V_1 \times F_3$ (PAC-60008 fertilized with NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}), $V_1 \times F_7$ (PAC-60008 fertilized with 50% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}), while the lowest one (15%) was found in $V_2 \times F_3$ (SV-887 fertilized with NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}). At 150 DAS, the highest brix (18%) was recorded in $V_1 \times F_7$(PAC-60008 fertilized with 50% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}) which was as good as the combination of $V_1 \times F_5$ (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}), $V_1 \times F_2$ (PAC-60008 fertilized with poultry manure @ 5 t ha^{-1}), $V_1 \times F_4$ (PAC-60008 fertilized with 75% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}) while the lowest brix (14.67%) was found in $V_2 \times F_2$ (SV-887 fertilized with poultry manure @ 5 t ha^{-1}) and $V_2 \times F_8$ (SV-887 with 75% NPK and other inorganic fertilizers + cowdung @ 5 t ha^{-1}).

CONCLUSION

From the findings of the present experiment, it can be concluded that sugarbeet variety PAC-60008 fertilized with 75% recommended dose of NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} appears as the promising combination in terms of beet yield.

Table-1 Interaction effects of variety and integrated nutrient management on plant height at different days after sowing of tropical sugarbeet

Interaction (Variety x integrated nutrient management)	Plant height (cm)			
	Days after sowing (DAS)			
	40	**60**	**80**	**100**
$V_1 x F_1$	19.75ef	32.50	41.08	40.67h
$V_1 x F_2$	21.67abc	36.17	43.08	44.08 g
$V_1 x F_3$	19.75ef	38.42	50.83	57.25a
$V_1 x F_4$	20.50cde	38.50	48.08	53.92abcd
$V_1 x F_5$	23.00a	39.75	49.08	51.08 de
$V_1 x F_6$	22.17ab	38.33	48.42	53.50bcd
$V_1 x F_7$	22.17ab	37.75	48.67	52.25cd
$V_1 x F_8$	20.08def	37.42	48.00	52.00cd
$V_1 x F_9$	20.50cde	38.33	48.17	55.17abc
$V_2 x F_1$	20.17def	33.17	41.33	45.92fg
$V_2 x F_2$	21.17bcde	35.75	44.58	48.33ef
$V_2 x F_3$	21.33bcd	39.17	51.00	54.50abcd
$V_2 x F_4$	20.42cdef	36.83	47.33	54.25abcd
$V_2 x F_5$	22.33ab	40.75	51.42	56.33ab
$V_2 x F_6$	20.25cdef	36.17	47.50	53.83abcd
$V_2 x F_7$	19.00f	34.83	46.42	51.08de
$V_2 x F_8$	21.50bcd	38.58	50.92	55.42abc
$V_2 x F_9$	20.33cdef	37.50	49.08	52.67bcd
$S\bar{x}$	0.435	0.764	0.893	1.12
Level of sig.	**	NS	NS	**
CV (%)	3.61	3.55	3.26	3.75

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT)
** =Significant at 1% level of probability. NS= Not significant
V_1 = PAC- 60008, V_2 = SV-887

F_1 = Cowdung @ 10 t ha^{-1}, F_2 = Poultry manure @ 5 t ha^{-1}, F_3 = Recommended dose of chemical fertilizer (NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}), F_4 = 75% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}, F_5 = 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}, F_6 = 50% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}, F_7 = 50% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}, F_8 = 75% NPK and other inorganic fertilizers + cowdung @ 5 t ha^{-1} and F_9 = 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}

Table-2 Interaction effects of variety and integrated nutrient management on number of leaves plant^{-1} at different days after sowing of tropical sugarbeet

Interaction (Variety x integrated nutrient management)	Number of leaves plant^{-1} Days after sowing (DAS)			
	40	60	80	100
V_1 x F_1	7.75cde	11.67ef	17.50defg	29.42de
V_1 x F_2	7.91abcd	11.42f	18.17cdefg	24.17i
V_1 x F_3	7.08f	11.83def	17.42efg	27.25fg
V_1 x F_4	7.00f	11.92cdef	16.92g	30.00d
V_1 x F_5	7.58def	11.83def	18.83bcde	25.83gh
V_1 x F_6	7.58def	12.58bcd	18.50cdef	28.42def
V_1 x F_7	7.92bcd	12.58bcd	18.25cdefg	27.67f
V_1 x F_8	7.25ef	11.67ef	17.25fg	29.83de
V_1 x F_9	7.75cde	12.42bcde	18.33cdef	29.58de
V_2 x F_1	8.00abcd	12.42bcde	18.58cdef	25.33hi
V_2 x F_2	8.58a	12.75bc	18.92bcd	29.67de
V_2 x F_3	8.50ab	13.00b	18.75bcde	33.17c
V_2 x F_4	8.00abcd	12.50bcde	19.25bc	28.17ef
V_2 x F_5	8.33abc	13.92a	21.42a	36.83a
V_2 x F_6	8.00abcd	12.92b	18.58cdef	34.92b
V_2 x F_7	7.25ef	12.17bcdef	18.08cdefg	32.08c
V_2 x F_8	8.16abcd	12.92b	20.00b	35.67ab
V_2 x F_9	7.91bcd	12.50bcde	18.42cdef	28.33def
$S\bar{x}$	0.198	0.265	0.424	0.540
Level of sig.	**	**	**	**
CV (%)	4.40	3.70	3.96	3.14

In a column, figures with same letter (s) or without letter do not different significantly whereas figures with dissimilar letter differ significantly (as per DMRT).
** =Significant at 1% level of probability. NS= Not significant
V_1 = PAC-60008, V_2 = SV-887

F_1 = Cowdung @ 10 t ha^{-1}, F_2 = Poultry manure @ 5 t ha^{-1}, F_3 = Recommended dose of chemical fertilizer (NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}), F_4 = 75% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}, F_5 = 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}, F_6 = 50% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}, F_7 = 50% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}, F_8 = 75% NPK and other inorganic fertilizers + cowdung @ 5 t ha^{-1} and F_9 = 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}

Table-3 Interaction effects of variety and integrated nutrient management on chlorophyll content at different days after sowing of tropical sugarbeet

Interaction (Variety x integrated nutrient management)	Chlorophyll content (SPAD value)			
	Days after sowing (DAS)			
	40	**60**	**80**	**100**
V_1 x F_1	29.73hi	37.63j	43.93g	40.27def
V_1 x F_2	33.10efg	46.87ghi	52.20f	41.83bcdef
V_1 x F_3	35.27cde	55.67cde	58.80e	44.40bcd
V_1 x F_4	31.27ghi	35.70j	46.97g	41.33cdef
V_1 x F_5	28.47i	46.50 ghi	46.43g	44.00bcde
V_1 x F_6	30.23ghi	48.40fgh	46.23g	40.87def
V_1 x F_7	29.27hi	44.77hi	53.50f	37.90f
V_1 x F_8	30.90ghi	47.10ghi	54.13f	39.07ef
V_1 x F_9	32.90efg	42.53i	58.37e	42.97bcde
V_2 x F_1	32.00fgh	50.70efg	68.40cd	46.07bc
V_2 x F_2	36.93bcd	52.77def	67.07cd	42.27bcdef
V_2 x F_3	37.90abc	58.70bc	85.63a	51.87a
V_2 x F_4	34.20def	52.53def	87.20a	42.17bcdef
V_2 x F_5	40.30a	66.33a	60.73e	42.83bcdef
V_2 x F_6	39.70ab	51.47efg	71.30c	46.47b
V_2 x F_7	37.30bc	48.10fgh	75.80b	43.33bcde
V_2 x F_8	35.33cde	62.47ab	66.33d	46.17bc
V_2 x F_9	36.73cd	56.77cd	85.27a	42.77bcdef
$S_{\bar{x}}$	0.917	1.60	1.46	1.48
Level of sig.	**	**	**	*
CV (%)	4.67	5.52	4.04	5.96

In a column, figures with same letter (s) or without letter do not different significantly whereas figures with dissimilar letter differ significantly (as per DMRT).

** =Significant at 1% level of probability.* =Significant at 5% level of probabilityNS= Not significant
V_1 = PAC-60008, V_2 = SV-887

F_1 = Cowdung @ 10 t ha^{-1}, F_2 = Poultry manure @ 5 t ha^{-1}, F_3 = Recommended dose of chemical fertilizer (NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}), F_4 = 75% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}, F_5 = 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}, F_6 = 50% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}, F_7 = 50% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}, F_8 = 75% NPK and other inorganic fertilizers + cowdung @ 5 t ha^{-1} and F_9 = 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}

Table-4 **Interaction effects of variety and integrated nutrient management on crop characters, yield components and yield of tropical sugarbeet**

Interaction (Variety x integrated nutrient management)	Top length (cm)	Top yield (t ha^{-1})	Root length (cm)	Beet girth (cm)	Average beet weight (kg)	Beet yield (t ha^{-1})
V_1 x F_1	34.27i	20.00i	23.70	29.30 h	0.27hi	26.67hi
V_1 x F_2	30.00j	21.67gh	22.83	30.00gh	0.30h	30.65h
V_1 x F_3	42.67de	36.00b	26.42	37.58ab	0.96a	95.52a
V_1 x F_4	38.75fg	26.67f	24.00	31.58fgh	0.86b	85.67b
V_1 x F_5	39.00fg	32.00c	27.00	38.58a	0.98a	98.18a
V_1 x F_6	41.00ef	29.67de	24.50	33.42cdef	0.69ef	68.93ef
V_1 x F_7	43.50d	30.33cd	22.00	34.00cdef	0.71e	71.07e
V_1 x F_8	38.00g	28.33e	24.92	31.83efg	0.79cd	79.33cd
V_1 x F_9	45.17bcd	38.67a	27.00	37.33ab	0.94a	94.33a
V_2 x F_1	37.25gh	20.33hi	23.17	29.33h	0.22i	22.10i
V_2 x F_2	35.33hi	23.00g	21.67	29.44h	0.27hi	27.38hi
V_2 x F_3	50.33a	38.33a	25.33	35.67bc	0.86b	86.03b
V_2 x F_4	43.73d	31.00cd	25.97	34.60cd	0.84bc	84.27bc
V_2 x F_5	46.92bc	36.00b	25.83	34.75cd	0.88b	88.00b
V_2 x F_6	45.17cd	30.67cd	22.17	32.58def	0.61g	61.27g
V_2 x F_7	43.00de	31.00cd	24.25	34.25cde	0.64fg	64.10fg
V_2 x F_8	47.50b	30.00d	25.00	33.92cdef	0.65fg	65.13efg
V_2 x F_9	43.42d	35.00b	25.08	34.33cde	0.77d	77.33d
$S\bar{x}$	0.766	0.547	0.787	0.763	0.018	1.99
Level of sig.	**	**	NS	**	**	**
CV (%)	3.21	3.17	5.58	3.95	4.37	5.08

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT)
** =Significant at 1% level of probability. NS= Not significant
V_1 = PAC- 60008, V_2 = SV-887

F_1 = Cowdung @ 10 t ha^{-1}, F_2 = Poultry manure @ 5 t ha^{-1}, F_3 = Recommended dose of chemical fertilizer (NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}), F_4 = 75% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}, F_5 = 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}, F_6 = 50% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}, F_7 = 50% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}, F_8 = 75% NPK and other inorganic fertilizers + cowdung @ 5 t ha^{-1} and F_9 = 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}

Table-5 Interaction effects of variety and integrated nutrient management on brix content (%) at different days after sowing of tropical sugarbeet

Interaction (Variety x integrated nutrient management)	Brix content (%) Days after sowing (DAS)		
	120	135	150
V_1 x F_1	14.00bc	15.67def	16.33bcd
V_1 x F_2	14.00bc	16.67abcd	17.00abc
V_1 x F_3	13.33cde	16.67abcd	15.67cde
V_1 x F_4	15.00ab	17.33ab	16.67abcd
V_1 x F_5	14.00bc	16.00cdef	17.50ab
V_1 x F_6	14.00bc	17.67a	16.00cde
V_1 x F_7	14.00c	16.67abcd	18.00a
V_1 x F_8	14.00bc	17.00abc	16.33bcd
V_1 x F_9	15.33a	17.33ab	16.00cde
V_2 x F_1	13.33cde	16.00cdef	15.67cde
V_2 x F_2	13.67cd	17.67a	14.67e
V_2 x F_3	12.00f	15.00f	15.67cde
V_2 x F_4	12.33ef	15.33ef	16.00 cde
V_2 x F_5	14.00bc	17.00abc	15.33de
V_2 x F_6	12.00f	15.67def	15.67cde
V_2 x F_7	13.33cde	16.33 bcde	15.67cde
V_2 x F_8	12.33ef	15.67def	14.67e
V_2 x F_9	12.67def	16.00cdef	16.33bcd
$S\bar{x}$	0.333	0.311	0.437
Level of sig.	**	**	**
CV (%)	4.26	3.28	4.71

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT)
** =Significant at 1% level of probability. NS= Not significant
V_1 = PAC- 60008, V_2 = SV-887

F_1 = Cowdung @ 10 t ha^{-1}, F_2 = Poultry manure @ 5 t ha^{-1}, F_3 = Recommended dose of chemical fertilizer (NPKSZnB @ 135-25-133-18-3.5-1.2 kg ha^{-1}), F_4 = 75% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}, F_5 = 75% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}, F_6 = 50% NPK and other inorganic fertilizers + cowdung @ 10 t ha^{-1}, F_7 = 50% NPK and other inorganic fertilizers + poultry manure @ 5 t ha^{-1}, F_8 = 75% NPK and other inorganic fertilizers + cowdung @ 5 t ha^{-1} and F_9 = 75% NPK and other inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}

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ADAPTABILITY OF PROMISING SUGARCANE CLONES/VARIETIES AT FARMER'S FIELD IN THAL AND SOUTHERN PUNJAB

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ABSTRACT

Some promising sugarcane clones/varieties of sugarcane research institute, Faisalabad which become moderately susceptible to red rot in North Punjab and some disease-free varieties were tested for their performance at five locations during February-March, 2016 in "Thal" and South Punjab. The trials were conducted at farmers' field using Randomize Complete Block Design (RCBD) with three replications. The data on germination%, tillers per plant, number of mill able canes, cane yield t/ha and commercial cane sugar %(CCS) were recorded during the course of study. The clone S2003-US-633 performed better as compared to other varieties with respect to yield. The CCS% of sugarcane clone S2003US-127 was statistically significant which was followed by others. In South Punjab S2006US-658 produced statistically significant cane yield.

INTRODUCTION

In Pakistan sugarcane is an important case crop. Sugarcane is grown on about one million hectares, with a total production of about 73 million tons (GOP 16-17). The contribution of the Punjab in the total cane production is around 60% sugarcane but varieties is one of the major factors responsible for low per acre sugarcane yield. Variety plays a fundamental key role both increasing and decreasing per unit-area sugarcane yield. Cultivation of good quality approved sugarcane varieties definitely improves yield, while use of unapproved inferior quality cane varieties effects sugarcane production negatively as situation prevails today. The sugarcane crop is planted around such areas where sugar mills are installed. "Thal" and Southern Punjab are the areas with low rainfall, less humidity and high temperatures. South Punjab is declared as Red Rot disease free zone. The varieties for example BF-162 and SPF-234, both are early maturing, high yielding good ratoon crop but susceptible to rust and red rot in central and north Punjab but produce high cane & sugar yields in South Punjab because it is declared as Red Rot disease free zone.

MATERIALS AND METHODS

The study was under taken on nine sugarcane varieties/ clones viz; S2003-US-127, S2003-US-633, S2006-US-658, S2008-FD-19, CPF-249, CPF-248, CPF-247 & CPF-246 (check variety) in "Thal" and South Punjab at four different locations during February-March 2016-17. The locations with varieties are as:

Sr. No.	Locations	Varieties
1.	Chak No.142/TDA Lalazar Layyah	S2003-US-127, S2003-US-633, S2006-US-658, S2008-FD-19, CPF-249, CPF-248, CPF-247 & CPF-246
2.	Chak No.327/E.B. Burewala	S2003-US-127, S2003-US-633, S2006-US-658, S2008-FD-19, CPF-249, CPF-248, CPF-247 & CPF-246
3.	MauzaAzeem Shah Khanpur	S2003-US-127, S2003-US-633, S2006-US-658, S2008-FD-19, CPF-249, CPF-248, CPF-247 & CPF-246
4.	Ittehad Sugar Mill Farm R.Y. Khan	S2003-US-127, S2003-US-633, S2006-US-658, S2008-FD-19, CPF-249, CPF-248, CPF-246&SPF-234

The experiments were laid out in Randomized complete block design (RCBD) with three replications and on an area of half an acre. Data on germination %, tillers/plant, mill able canes/ha, cane yield tones/ha and CCS% were recorded. Visual observations on disease information were also recorded. The collected data were analyzed statistically by employing the Fisher's analysis of variance technique (Steel *et al.*, 1997) using Statistix 8.1 (Analytical software, Statistix; Tallahassee, FL, USA, 1985-2003) compare the differences among treatments means with LSD test at 0.05 probability level.

RESULTS AND DISCUSSION

Chak No.142/TDA Lalazar, Layyah

A glance at the data given in table-1 revealed that variety CPF-249 and S2006-US-658 has out yielded all other the varieties significantly. The maximum cane yield produced by the variety can be attributed to higher tillers/plant and no. of canes/ha. The maximum CCS % was produced by the clone S2003-US-127 while S2006-US-658 and CPF-246 produced least CCS%. Clone S2003-US-778 showed the maximum germination percentage whereas S2008-FD-19 produced most tillers per plant. The results reported by Sarwar *et al*., (2016) are in accordance with the present findings.

Chak No.327/E.B. Burewala

All the varieties showed better germination % with CPF-247 at the top table-3. The maximum significant tillers/plant was given by S2008-FD-19 and CPF-249. The maximum no. of mill able canes/ha has direct effect on cane yield, hence S2008-FD-19 and S2006-US-658 has produced significantly the maximum cane yield t/ha and the lowest by CPF-248. Sarwer *et al.,* (2001) revels the results similar to the present findings. CPF-247 has shown the highest ccs% the variety S2008-FD-19 statistically at par with CPF-247 however, CPF-249 produced less ccs%.

Mauza Azeem Shah, Khanpur

Significantly the maximum germination% was given by the variety CPF-246, however variety S2006US-658 statistically at par. The variety S2008FD-19 gave the lowest germination% but produced significantly more tillers/plant as compared to other given in table-4. The variety S2006-US-658 gave significantly more cane yield, However, clones/varieties S2003-US-633, CPF-249 and CPF-246 are statistically at par with the aforesaid. The variety CPF-248 produced the less cane yield t/ha than the prior mentioned varieties. The standard variety CPF-248 had produced maximum ccs % and is followed by S2006-US-658. Aslam *et al*., (1998) expressed variations in different cane yield parameters of cane varieties.

Ittehad Sugar Mill, R.Y.Khan

The data given in table revealed that the variety CPF-246 gave the significantly higher germination% but the variety SPF-234 produced lowest germination%. Maximum tillers/plant were obtained by variety CPF-249 &SPF-234 however, varieties S2006-US-658, S2008-FD-19, S2003-US-633 and CPF-248 are statistically at par with the prior mentioned varieties. The sugarcane variety CPF-246 have produced significantly higher no. of millable canes/ha however, variety S2008-FD-19 statistically at par with CPF-246 variety S2003-US-127 had produced the less no. of millable canes/ha. Maximum cane yield t/ha produced by varieties S2006-US-658, S2003-US-633, CPF-249, S2003-US-127 and CPF-246 respectively, however, variety S2008-FD-19 statistically at par with the aforesaid varieties. The ccs% of S2006-US-658 is the maximum among the cane varieties under test.

Summary

The summary table depict that the sugarcane clones/varieties S2006-US-658, S2008-FD-19 and S2003-US-633 increased 22.3%, 9.0% and 1.8% cane yield tonnes/ha over the check variety i.e. CPF-247. The sugarcane variety S2003-US-127 showed the less cane yield percent i.e. 6.4%. Whereas, increase ccs % concerned the sugarcane clones/varieties that's are S2008-FD-19, S2003-US-127, S2003-US-633 and S2006-US-658 produced 5.0%, 3.7%, 1.7% and 0.1% increase ccs% over the check variety CPF-247.

Table-1 Chak No.142/TDA Lalazar, Layyah

Sr. No.	Varieties / clones	Germ. %	Tillers / plant	Canes / Ha	Yield (t/ha)	CCS %
1.	S2008-FD-19	62.96 ab	1.92 a	173.60 a	107.00 b	12.63 c
2.	S2006-US-658	57.90 bc	1.78 ab	168.07 a	112.37 ab	11.70 d
3.	S2003-US-633	55.18 cd	1.76 ab	161.10 a	88.87 c	13.92 a
4.	S2003-US-127	48.89 d	1.62 ab	143.10 b	90.23 c	13.51 ab
5.	CPF-249	49.14 d	1.75 ab	130.50 bc	123.53 a	12.60 c
6.	CPF-248	63.70 ab	1.65 ab	131.97 bc	84.70 c	12.59 c
7.	CPF-247	68.02 a	1.27 b	115.63 c	86.13 c	12.70bc
8.	CPF-246 (check)	55.35 cd	1.19 b	130.15 bc	82.21 c	11.35 d
LSD at 0.05		**7.05**	**0.56**	**17.88**	**15.42**	**0.82**

Table-2 Chak No.327/E.B.Burewala

Sr. No.	Varieties / clones	Germination %	Tillers / plant	Canes / ha	Yield (t/ha)	CCS %
1	S2008-FD-19	58.99 b	1.63 a	203.3 a	165.0 a	12.80 ab
2	S2006-US-658	59.48 b	0.53 c	196.7 b	171.6 a	10.89 d
3	S2003-US-633	66.59 ab	1.01 b	170.3 b	111.5 c	13.10 a
4	S2003-US-127	69.78 a	1.44 a	181.6 ab	140.3 b	12.54abc
5	CPF249	60.70 b	1.48 a	206.6 a	106.0 d	12.07bc
6	CPF 248	60.66 b	0.41 c	126.6 c	74.33 e	12.11bc
7	CPF 247	71.50 a	0.53 c	186.6 ab	120.0 c	11.89 c
8	CPF 246 (check)	63.57 b	1.03 b	173.3 b	139.3 b	11.80 c
LSD at 0.05		**7.44**	**0.45**	**22.93**	**13.88**	**0.87**

Table-3 MauzaAzeem Shah Khanpur

Sr. No.	Varieties / clones	Germination%	Tillers / plant	Canes / ha (000)	Yield (t/ha)	CCS %
1	S2008-FD-19	31.85 c	3.07 a	83.37 c	105.0 b	12.54
2	**S2006-US-658**	**56.94 a**	**2.91 b**	**116.6 a**	**116.6 a**	**11.27**
3	S2003-US-633	46.48 b	2.27 b	104.4 ab	113.3 ab	12.99
4	S2003-US-127	51.19 ab	2.02 b	105.1 ab	109.3 ab	12.06
5	CPF-249	41.39 b	1.86 b	103.3 ab	114.9 ab	11.92
6	CPF-248	42.94 b	1.83 b	99.62 bc	93.4 c	11.57
7	CPF-247	37.60 c	1.91 b	96.61 bc	97.5 c	11.84
8	CPF 246 (check)	41.89 b	1.77 b	95.01 bc	98.3 c	11.60
LSD at 0.05		**8.48**	**0.73**	**14.37**	**10.52**	**N.S**

Table-4 MauzaAzeem Shah Khanpur

Sr. No.	Varieties / clones	Germination %	Tillers / plant	Canes / ha (000)	Yield (t/ha)	CCS %
1.	S2008-FD-19	37.31 cd	1.94 ab	108.33 ab	95.36 ab	11.89
2.	**S2006-US-658**	**44.91 bc**	**1.95 ab**	**93.65 cd**	**103.32 a**	**10.70**
3.	S2003-US-633	52.87 b	1.71 ab	104.48 bc	101.66 a	13.03
4.	S2003-US-127	37.31 cd	1.33 b	85.04 d	99.85 a	12.09
5.	CPF-249	50.65 b	2.34 a	103.33 bc	101.66 a	12.11
6.	CPF-248	51.11 b	1.63 ab	94.92 cd	86.70 b	12.02
7.	CPF-247	33.79 d	2.15 a	90.03 d	85.04 b	12.52
8.	CPF-246 (check)	68.33 a	1.42 b	119.95 a	98.34 a	11.27
LSD at 0.05		**10.05**	**0.73**	**12.99**	**12.85**	**N.S**

Summary Table: Pooled means of 4 locations for 8 clones/varieties during 2016-17

Sr. No.	Variety	Yield	Increase Yield %	CCS%	Increase CCS %
1	S2008-FD-19	118.1	13.0	12.5	8.3
2	S2006-US-658	126.0	20.5	11.1	-3.2
3	S2003-US-633	103.8	-0.7	13.3	15.3
4	S2003-US-127	109.9	5.1	12.6	9.1
5	CPF-249	111.5	6.7	12.2	5.8
6	CPF-248	84.8	-18.9	12.1	4.9
7	CPF-247	97.2	-7.1	12.2	6.4
8	CPF-246 (check)	104.5	0.0	11.5	0.0

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SUGAR INDUSTRY ABSTRACTS

Legal and trust issues in Australian Agriculture
L Wiseman, J Sanderson
Proceeding of Australian Society of Sugar Cane Technologists, Vol. 40: 2018 p 1-9.

It is well accepted that the use of digital technology and agricultural data has the potential to transform agriculture and agribusiness. Agricultural data can aid analysis, provide early warnings, enable accurate predictions that result in improved productivity. Currently, however, the regulatory frameworks around data collection, sharing and use in Australia are ad hoc and piecemeal. In this paper, some of the key reasons why many farmers are refraining or restricted from sharing data, including the lack of transparency around issues such as data ownership, portability, privacy, trust and liability, are outlined. These fears are evident and are addressed in many of the key findings of the Australian Commonwealth Department of Agriculture's Rural for Profit Research Grant, Accelerating Precision Agriculture to Decision Agriculture: enabling digital agriculture in Australia. To conclude, this paper will examine how best to facilitate the improved data governance framework needed to support and encourage the use and adoption of digital technology and data for the benefit of all agricultural industries.

From sugar mill to biorefinery: determining the global warming potential of upgrading a centenary factory
JB Melendez, T Gardner, Y Viera
Proceeding of Australian Society of Sugar Cane Technologists, Vol. 40: 2018 p 10-16.

Based on the Life Cycle Assessment (LCA) a scoping review of the Global Warming Potential (GWP) of a multipurpose sugarcane biorefinery is presented. The Mossman sugar mill was assessed as an example for its potential transformation into a multi-product factory that adds value to all by-products and crop residues. A baseline scenario (S1) was established using the current production system, which produces sugarcane, sugar, molasses and electricity. The addition of industrial units to produce ethanol from molasses (S2), single-cell protein (SCP) from vinasse (S3), and bio-naphtha/electricity from crop residues (S4) completed the four scenarios under evaluation. Each system boundary was determined by the mass allocation method (MA). The accumulative GWP of sugarcane production was the highest, followed by sugar and bio-naphtha. As new industrial units were incorporated into the baseline scenario, S3 and S4 increased its total GWP by 30% and 86% respectively, while S2 was reduced by 1.7% compared with S1. An overall increase of GWP was observed by the change of a traditional sugar mill into a Biorefinery. However, the bio-naphtha, electricity and ethanol obtained with the design resulted in significantly less CO2 emissions than conventionally produced products. According to the studies surveyed most of the Green House Gases (GHG) emissions occurs during the field operations and not in the factory process. A detailed LCA study for the transformation of Mossman sugar mill into a Biorefinery should emphasise sugarcane production, transportation, and trash collection as the major sources of GHG.

The weather experienced by sugarcane production systems in northern Queensland has changed over the past 80 years

GD Bonnett

Proceeding of Australian Society of Sugar Cane Technologists, Vol. 40: 2018 p 16-23.

There Is Increasing evidence that the environmental potential for Australian cropping production systems has changed measurably over the past hundred years. Analysis of rainfall records in the Western Australia wheat belt has shown a significant decrease in in-season rainfall over that period. Across the whole of the Australian wheat belt both an increase in temperature and a decrease in rainfall have been known to lead to a decrease in the environmentally determined yield potential and a possible contributor to stalled wheat yield per area in Australia. In a recent investigation of CCS trends in the northern sugar growing region around Mulgrave Mill, the weather records of the region were analysed. Rainfall and maximum and minimum temperatures from the Cairns region date back to the late 1800s and early 1940s respectively. The monthly rainfall, maximum and minimum temperatures were analysed using linear regression and comparison with the 1961–1990 average (anomaly analysis commonly used in climate research). The results show that for many months of the year there has been an increase in the average maximum and minimum temperatures of over 1 °C in the past 70 years. For rainfall the effect was less clear and most marked in the harvesting season in October. The results are discussed in relation to the growth and development processes of sugarcane and other operations in the sugar production system. These results demonstrate that climate change is not only a future consideration but there has already been measurable change. Further analysis across the whole industry would be a useful next step to determine more broadly the changing environment sugarcane production systems are operating under.

Australian sugar industry training learning management system

D Moller, B King

Proceeding of Australian Society of Sugar Cane Technologists, Vol. 40: 2018 p 24-32.

Through funding from Sugar Research Limited (SRL) and Sugar Research Australia (SRA), an Australian sugar industry Learning Management System (LMS) is being developed. The objective of the Australian Sugar Industry Training (ASIT) project is to provide an LMS to the Australian sugar industry that has a one-step login to access all of the sugar industry training material. The system also needs to be easy to navigate, while using a variety of genres to transfer knowledge. The LMS aims to create a learning pathway and environment that is enjoyable, informative and uses a variety of approaches to engage the learner, has knowledge that is accurate, using common industry terminology and visual displays to enhance learning and provides assessment that is varied, providing statistical feedback to the learner of their progress. The cost of the access per individual to the LMS training material needs to be affordable. It is planned that the LMS will become a major source of content training materials for Australian sugar industry containing SOTrain, (Supervisor and Operator Training), SRM (Sugar Research Modules), SRI (Sugar Research Institute) videos and new training materials as they are developed. Each module is planned to provide an online knowledge training tool and knowledge competency assessment system for the Australian sugar industry mapped to the FDF10 competencies from the Australian Government training website at Certificate III level. This paper describes the process used to select the LMS provider, key features of the LMS and how the features can be effectively used by the Australian sugar industry. It also discusses the capacity of the LMS to allow individual Australian sugar companies to develop their own material.

Sugar from space: using satellite imagery to predict cane yield and variability
JS Muir, AJ Robson, MM Rahman
Proceeding of Australian Society of Sugar Cane Technologists, Vol. 40: 2018 p 33-40.

Satellite imagery has been demonstrated to be an effective technology for producing accurate pre-harvest estimates in many agricultural crops. For Australian sugarcane, yield forecasting models have been developed from a single date SPOT satellite image acquired around peak crop growth. However, a failure to acquire a SPOT image at this critical growth stage, from continued cloud cover or from competition for the satellite, can prevent an image being captured and therefore a forecast being made for that season. In order to reduce the reliance on a single image capture and to improve the accuracies of the forecasts themselves, time series yield prediction models have been developed for eight sugarcane growing regions using multiple years of free Landsat satellite images. In addition to the forecasting of average regional yield, an automated computational and programming procedure enabling the derivation of crop vigour variability (GNDVI) maps from the freely available Sentinel 2 satellite imagery was developed. These maps, produced for 15 sugarcane growing regions during the 2017 growing season, identify both variations in crop vigour across regions and within every individual crop. These outputs were made available to collaborating mills within each growing region. This paper presents the accuracies achieved from the time series yield forecasting models versus actual 2017 yields for the respective regions, as well as provides an example of the derived mapping outputs.

Effects of compost and mill mud/ash on soil carbon and the nematode community in a field trial on sugarcane at harwood, new south wales
Gr Stirling, Aj Young, Rl Aitken, Rn Beattie, A Munro
Proceeding of Australian Society of Sugar Cane Technologists, Vol. 40: 2018 p 41-49.

A field trial at Harwood, New South Wales compared an amendment of mill mud/ash with compost produced from mill mud/ash, bagasse and wood waste. The trial contained 13 treatments (compost at 13, 26, 55 and 66 dry t/ha; mud/ash at 15, 30, 58 and 90 dry t/ha; and urea at 0, 40, 82, 140 and 230 kg N/ha). Data collected from the two-year-old plant crop showed that both amendments improved sugarcane yield and that the response increased as the amendment rate increased. Analyses of soil organic carbon following plant crop harvest showed that both mud/ash and compost increased total carbon levels by 7–10%. Given the central role of carbon in improving a soil's physical and chemical properties, this increase was probably one of the reasons yield responses were obtained. However, data obtained from analyses of the nematode community indicated that biological factors were also involved. Two years after the mud/ash was applied, populations of root-lesion nematode (Pratylenchus zeae), an economically important pest of sugarcane, were reduced by about 60%, while compost increased populations of microbivorous nematodes, a group of nematodes that improve plant nutrition through their involvement in nutrient mineralisation processes. Analyses undertaken after the ratoon crop was harvested two years later showed that soil carbon levels in the amended soils were still significantly higher than the non-amended control and that both amendments had reduced populations of stunt nematode (Tylenchorhynchus annulatus), one of the five plant-parasitic nematode found at the site.

INTERNATIONAL EVENTS CALENDAR

2018 MEETINGS AND CONFERENCES

August 3-8: 35th International Sweetener Symposium, The Grand Traverse Resort, Traverse City MI USA, ASA

August 21-24: *ISSCT CO- Products Workshop* Campinas, São Paulo, BRAZIL.

September 3-7: ISSST Workshop, Challenges and Advances in Sugarcane Pathology – A key to re solve emerging issues and to formulate innovative disease management strategies, Coimbatore, INDIA.

September 23-28: Joint ISSCT Agricultural Engineering, Agronomy and Extension Workshop Saint-Gilles, Reunion ISLAND.

September 24-28: Association of Latin American Sugar Technologists (ATALAC), Colombia ATALAC

October 22-26: ISSCT joint Breeding & Germplasm and Molecular Biology Workshops Okinawa, JAPAN.

STORY OF SWEETS

i. Imarti

Ingredients

Split Black Gram 1 cup
Rice Flour
Rice 1/4 cup
Edible orange red colour as required
Sugar 5 cups
Saffron (kesar) a pinch
Rose essence 6 drops
Green cardamom powder 1 teaspoon
Olive oil to deep fry

Method

Step-1 Soak dal and rice together for about forty-five minutes. Drain and grind with the colour to a soft, spongy mixture with a coarse texture.
Step-2 You would need about one cup of water to grind. The batter should not become too thin.
Step-3 Boil sugar with two and a half cups of water till a syrup of single-thread consistency is reached. Remove from heat and strain the syrup.
Step-4 Add saffron, rose essence and green cardamom powder. Keep the syrup hot.
Step-5 Heat sufficient olive oil in a shallow flat jalebi kadai (special type of wok). Take one ladle full of batter in the imarti cloth, hold tightly and press the batter through the hole into the hot oil.
Step-6 For the traditional design, make a small circle around which make another circle and over these two make scallops in anti-clockwise direction ending at the starting point.
Step-7 Make small batches and deep fry on both the sides till crisp and light golden brown. Drain the hot imarti and dip into the sugar syrup.
Step-8 Let them remain immersed till they have absorbed enough syrup. Drain and place the imarti on a flat plate. Repeat this process till all the batter is used up. Serve hot.

ii. Petha Kaddu

Ingredients

500 grams winter melon/ Ash gourd/ Petha kaddu
150 grams sugar
6-7 drops screwpine/ kewra essence
1 tsp edible limestone/ chuna

Method

Step-1 Cut winter melon into circular ring. Remove centre soft part of winter melon. Cut rest of the circular part in petha shape. Now check cut petha pieces and if you see any soft part discard them. Peel petha skin and make sure green part is not left. Scrub the side with knife that had green skin. This will help in even coating of sugar. Take a tooth pick and prick petha pieces from all the sides.
Step-2 In a large bowl add enough water add 1 tsp edible limestone. There are two main reasons for adding limestone. Itmakes pethas firm and help in retaining white color. Add petha pieces in limestone water and leave it for 8 hours.
Step-3 Take out from limestone water after 8 hours and rinse well atleast 3-4 times. In a pan boil 3 cups of water on medium heat. In boiling water add petha pieces and cook for 5 minutes. After 5 minutes, check petha with a tooth pick. Petha will turn soft. Turn off heat and take it out in chilled water. It will stop cooking process.
Step-4 Transfer pethas in another vessel and add 150 grams of sugar. Toss it well and coat pethas evenly. Sugar will start dissolving soon. Cover it and leave it for an hour.
Step-5 After an hour sugar is dissolved. Turn on heat on low medium and cook pethas. Add kewra essence (6-7 drops) and make sure not to pour over petha. Mix well and cook for 3 minutes. Switch heat on medium and cook for 7 minutes while stirring slowly. Cook 2-3 minutes more on medium-high heat. Sugar will be almost over and sugar syrup will be very thick. When sugar is almost over, that is the right time to take out pethas. Using a tong take out pethas one by one on cooling rack. Switch heat on low medium while taking out pethas. Immediatelycrystallization of sugar will start. Leave it under running fan for 8-10 hours. Then petha will be ready. It will be firm from outside and slightly juicy from inside. Very delicious petha is ready. Enjoy eating this delicacy and relive your memories!

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