Research Article

Ratooning Potential of Different Promising Sugarcane Clones under Varying Trench Spacing

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Abstract | Planting patterns have a crucial role in cane and sugar yield. This investigation was performed to determine the ratooning potential of diverse clones of sugarcane under different trench spacing. The study was comprised of different trench spacing i.e., 90, 120, 150 and 180 cm and diverse sugarcane clones i.e., US-272, US-658, US-127 and US-704. The study was conducted in a randomized complete block design with split plot arrangement having three replications. The findings depicted that trench spacing and clones significantly affected sugarcane growth, cane yield and sugar yield. The maximum cane length (250.69 cm), mill-able canes (13.83) and stripped cane yield (107.67 t ha^{-1}) were recorded in 120 cm apart-trenches, whilst minimum cane length (229.11 cm) mill-able canes (12.00) and stripped cane yield (98.17 t ha^{-1}) was noticed in 90 cm spaced trenching. In the case of clones, US-272 had maximum cane length (255.03 cm), un-stripped cane yield (139.43 t ha^{-1}) and stripped cane yield (109.75 t ha^{-1}). Moreover, trench spacing did not affect brix (%), sucrose content SC (%), cane juice purity (CJP) and commercial cane sugar (CCS) (%), however, trench spacing significantly affected the sugar yield. The maximum sugar yield (13.51 t ha^{-1}) was obtained in 120 cm apart trenches and the minimum sugar yield (11.56 t ha^{-1}) was obtained in 90 cm spaced trenches. Amongst clones, maximum brix (24.01%), SC (17.96%), CJP (80.38%), CCS (12.51%) and sugar yield (13.62 t ha^{-1}) were recorded in US-127 and the lowest was noted in US-704 among the clones. In conclusion, sowing in 120 cm apart trenches is a promising practice to obtain the maximum cane and sugar yield from the ratooned sugarcane crop.

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1. Introduction

Sugarcane is an imperious sugar crop of Pakistan and it has a contribution of 0.6% in GDP and 2.9% in the value added by the agriculture sector (GoP, 2020). Pakistan ranks at 5th position regarding the area of production, whilst, it occupies 8th position regarding the production amid the 104 sugarcane producing countries worldwide (FAO, 2017). The average sugarcane yield of Pakistan is 55.6 t ha^{-1} that is quite lower than other advanced countries i.e., Australia, Brazil, USA, China and India (FAO, 2017;

Nawaz *et al*., 2017; GoP, 2017). The sugar industry in Pakistan is the second largest industry after the textile industry (Nawaz *et al*., 2019) and Pakistan is the 9th largest sugarcane grower in the world (Chattha *et al*., 2017a).

Sowing methods play an important role in the growth and final production owing to fact they significantly affect germination and stand establishment (Chattha *et al*., 2017b). The traditional planting methods are the chief cause of the lower crop production (Hassan *et al*., 2019a; Chattha *et al*., 2020) and cane productivity in Pakistan (Aamer *et al*., 2017). Moreover, low plant population, plant lodging, thinner and dwarfed canes are considered to be the main causes of low production in conventional planting methods (Ehsanullah *et al*., 2011). Sugarcane cultivated by conventional planting method at 60-75 cm apart single enhance the number of plants per unit, however, in this method different management practices are very difficult to perform which are adequate for the proper and uniform stand establishment. Therefore, to ensure desired production and to meet the sugar needs planting methods should be optimized to minimize the gap between potential and actual yield. Lodging is considered as one of the severe problems of lower sugarcane production in Pakistan. The sugarcane yield, juice quality, and sugar recovery is considerably decreased due to crop lodging (Heerden *et al*., 2015). The wider row trenches have an appreciable potential to improve the sugarcane yield in Pakistan (Ullah *et al*., 2016). Sugarcane plantation in trenches by using the recommended seed rate is a more appropriate and effective method to obtain higher production compared to the conventional method (Bhullar *et al*., 2008).

The ratooning is a technique of raising a full crop of sugarcane from stubbles of the previous crop. Sugarcane ratoon crop is also very exhaustive crop like the main crop. The ratoon crop of sugarcane needs more nitrogen application because of immobilization, shallow and decayed older roots of ratoon. Therefore, in ratoon crop 20 to 30% more nitrogen should be used as compared to the main crop (Lal and Singh, 2008). The ratooning of sugarcane is considered more economical because it does not need any seed and it saves the planting operations. The ratoon crop of sugarcane also prolongs the crushing time period of sugar mills because it matures early than the main sugarcane crop. Nonetheless, the ratoon crop has less production than the main crop (Shukla *et al*., 2013). The selection and cultivation of suitable cultivars play a crucial role in the final yield and biomass production (Hassan *et al*., 2018; 2019a; 2020). Likewise, the cultivation of appropriate sugarcane genotypes also plays an appreciable role in the final cane and sugar yield. Singh and Dey (2002) observed the clear difference among the clones for growth, cane yield and final sugar yield. The ratooning is considered to be the behavior of genotype and environment. Therefore, it is mandatory to identify genotypes with good ratooning abilities. Therefore, the current study was performed to determine the ratooning ability of various sugarcane clones under different trench spacing.

2. Material and Methods

2.1. Experimental site, soil and climatic conditions

This study was performed at the Agronomic Research Area of the University of Agriculture Faisalabad during 2016-2017. The study site falls in semi-arid region, whilst, other weather conditions during the growing period are given in Table 1. The soil samples were taken from various points of the field with the soil auger, homogenized and analyzed to determine the various soil physical and chemical properties (Homer and Pratt, 1961). The soil had pH 7.83, organic matter 0.76%, total nitrogen (N) 0.014%, extractable phosphorus (P) 6.33 ppm and exchangeable potassium (K) 181 ppm, respectively.

Table 1: Prevailing weather conditions during the growing period.

Months	Monthly average temperature (°C)	Relative humidity	Rainfall (mm)
Sep-16	31	53.6	12
Oct-16	26.7	51.3	22.2
Nov-16	20.1	60.1	0
Dec-16	16.4	68.7	0
Jan-17	12.9	72	11.5
Feb-17	16.8	53	4.1
Mar-17	20.7	49.5	16.2
Apr-17	29.3	30.6	28.3
May-17	33.5	29.8	10.1
June-17	33.5	44.5	41.6
July-17	33.7	70	117.2
Aug-17	33.4	68.9	66
Sep-17	30.5	67,5	35.6

2.2. Crop husbandry

The soil was ploughed three times and planked to prepare the seedbed for the sowing of main sugarcane crop. The net plot size was 12 m x 3.6 m for 0.9 m apart trenches, and for 1.5 m and 1.8 m apart trenches the net plot size was 12 m × 9 m. The sowing was done using 75000 double budded setts per hectare. The sugarcane clones i.e., US-272, US-127, US-658 and US-704 were kept in subplots while, trench spacing viz. 90 cm, 120 cm, 150 cm and 180 cm apart trenches were kept in the main plot. Fertilizers (NPK) were used at rate of 218-145-145 kg ha^{-1}. The sources of NPK fertilizers were; urea (46% N), di-ammonium phosphate (46% P and 18% N) and suphate of potash (50% K). 50% N and 100% K and P was applied at sowing and the remaining 50% N used in two splits. Irrigation was given to crop as and when needed and total 16 irrigations were applied. All the other management practices were kept uniform to ensure good stand establishment.

2.3. Field measurements and qualitative analysis

Ten plants from every plot were selected; plant height and cane length was measured and averaged. Similarly, millable canes were counted by selecting an area of 1 m^2 from each plot. Total canes from each plot were harvested and weighed to determine the un-stripped cane yield, thereafter, tops and trash were removed from canes and weighed to determine the stripped cane yield (SCY). The brix concentration, sucrose contents (SC), cane juice purity (CJP), commercial cane sugar (CCS) were determined by the standard procedures of Spancer and Meade (1963). Moreover, total sugar yield was calculated by the following formula.

$$\text{Total sugar yield} = \frac{\textit{Stripped cane yield } t\ \text{ha} - 1\ \times CSR\%}{10}$$

2.4. Experimental design and statistical analysis

The study was conducted in RCBD in a split arrangement with three replications. The data on different characters were analyzed by Fisher's analysis of variance technique and LSD test was performed at 5% probability level to separate the treatment means (Steel *et al*., 1997).

3. Results and Discusiion

The findings showed of diverse trench spaces significantly affected the plant height, can length and millable canes (Table 2). The taller plants (436 cm) were noticed in 150 cm apart trenches, whilst the shortest plants (416 cm) were noted in 90 cm apart trenches (Table 2). Likewise, trench spacing also significantly affected the unstripped and stripped cane yield (SCY). Sowing in 150 cm apart trenches remained at top ranking with maximum un-striped yield (138.79 t ha^{-1}), while sowing in 120 spaced tranches remained at the top position with maximum SCY (107.67 t ha^{-1}), which was also comparable with the 150 cm apart trenches. Moreover, the lowest unstripped cane yield (127. 67 t ha^{-1}) and SCY (98.17 t ha^{-1}) were obtained in 90 cm apart trenches (Table 2).

In the case of clones the taller plants (443.08 cm) were recorded for US-127, followed by US-272, whereas the shortest plants (411.25) were recorded for US-704. Clone US-272 remained at top position with maximum cane length (255. 03 cm) after that US-127 that was comparable with US-272 and US-658. Likewise, the maximum millable cane (13.41) was recorded in US-127, whereas the minimum millable canes (12.25) were recorded for US-704. Moreover, maximum unstripped cane yield (139.43 t ha^{-1}) and SCY (109.75 t ha^{-1}) were produced by US-272, followed by US-127, whereas the minimum unstripped cane yield (128.13 t ha^{-1}) and SCY (96.76 t ha^{-1}) were recorded for US-704 (Table 2).

The results indicated that trench spacing had a non-significant effect on the quality attributes, i.e., brix, SC, CJP and CCS while trench spacing had a significant impact on the total sugar yield (Table 3). The maximum sugar yield (13.51 t ha^{-1}) was recorded in 120 cm apart trenches that were comparable with 150 cm spaced trenches and minimum sugar yield (11.56 t ha^{-1}) was obtained from 90 spaced trenches. Conversely, clones had a significant impact on the qualitative attributes. The maximum brix (24.01%) and SC (17.96%) were noted in US-127, followed by US-658, whereas lowest brix (22.57%) and SC (17.46%) were noticed in US-704 (Table 3). Likewise, maximum CJP (80.38%), CCS (12.51%) was also recorded for US-127 that was comparable with the US-272, whereas the minimum CJP (72.86%), CCS (10.74%) was noted in US-704 (Table 3). Moreover, maximum sugar yield (13.62 t ha^{-1}) was noted in US-127, which was comparable with US-272 while minimum sugar yield (10.89 t ha^{-1}) was noticed in US-704 (Table 3).

This study was done to determine the impact of trench spacing and clones on the ratooned crop of sugarcane.

Table 2: Effect of tranche spacing and clones on growth, yield and yield related characters.

Trench spacing (TS)	Plant height (cm)	Cane length (cm)	millable canes	Un-Stripped cane yield (t ha^{-1})	Stripped cane yield (t ha^{-1})
90 cm	415.58 C	229.11 B	12.00 C	127.66 C	98.17 C
120 cm	426.92 B	250.69 A	13.83 A	136.58 A	107.67 A
150 cm	436.00 A	237.48 B	12.83 B	138.79 A	104.67 AB
180 cm	420.17 BC	235.69 B	12.41 BC	130.95 B	102.18 BC
LSD≤0.05P	6.87	11.95	0.81	2.45	4.80
Clones (C)					
US-272	430.08 B	255.03 A	13.08 A	139.43 A	109.75 A
US-658	414.25 C	239.58 B	12.33 B	132.16 B	100.83 C
US-127	443.08 A	241.50 B	13.41 A	134.25 B	105.33 B
US-704	411.25 C	216.27 B	12.25 B	128.13 C	96.76 C
LSD≤0.05P	10.30	7.56	0.66	2.68	4.22
TS×C	NS	NS	NS	NS	NS

The mean values sharing different letters differed at 0.05% probability level.

Table 3: Effect of tranche spacing and clones on qualitative attributes.

Trench spacing (TS)	Brix (%)	Sucrose (%) in juice	Cane juice purity (%)	Commercial cane sugar (%)	Total sugar yield (t ha^{-1})
90 cm	22.99	17.40	76.68	11.63	11.56 C
120 cm	23.12	17.42	77.48	11.76	13.51 A
150 cm	23.10	17.35	76.62	11.60	12.88 A
180 cm	23.40	17.17	75.94	11.22	12.67 B
LSD≤0.05P	NS	NS	NS	NS	0.43
Clones (C)					
US-272	23.04 B	17.79 A	79.86 A	11.88 B	13.25 AB
US-658	22.99 B	17.96 A	73.62 B	11.09 C	12.86 B
US-127	24.01 A	17.96 A	80.38 A	12.51 A	13.62 A
US-704	22.57 C	17.46 B	72.86 B	10.74 D	10.89 C
LSD≤0.05P	0.36	0.30	1.11	0.15	0.70
TS×C	NS	NS	NS	NS	NS

The mean values sharing different letters differed at 0.05% probability level.

The maximum plant height was noted in the 150 cm apart trench and maximum cane length was observed in 120 cm apart trenches and the minimum was observed in the 90 cm spaced trenches. The taller and thicker plants in wider spacing attributed to better use of light and circulation of air which resulted in more assimilate production owing to improvement in the process of photosynthesis. The better production of assimilates in wider spacing was responsible for the production of taller and thicker plants as compared to narrow spacing. Earlier different authors also noticed the taller plants in wider row spaces compared to narrow row spaces (Yadav, 2004; Maqsood *et al*., 2005). Similarly, trench spacing also significantly influenced the un-stripped and SCY. The higher un-stripped cane yield in wider space can be due to more millable canes, cane length, cane diameter and cane top weight. Likewise, Cheema *et al*. (2002) also obtained the higher un-stripped cane yield with wider spacing compared to narrow spaces. The higher cane yield in 120 cm apart trenching was due to the production of taller canes with more stripper cane weight. These findings are the same as reported by Bashir *et al*. (2005) they described that wider row spacing considerably increased the stripped cane yield.

Clones also had differential responses for growth and yield. The maximum plant height was observed in US-127, while maximum cane length and millable cane were observed in US-272. The difference amongst the clones for plant height and cane length can be ascribed to differences in their genetic potential for plant height, cane length and millable canes. Likewise, clones also had significant differences for the un-stripped cane yield and SCY. Clone US-127 had maximum un-stripped cane yield and SCY which can be attributed to taller canes with more weight per striped cane as compared to other clones. Previously, Islam *et al*. (2011) also observed the considerable differences among clones for the cane length, cane yield and sugar yield.

Trench spacing had a non-significant effect on the brix, SC, CJP and CCS (Table 3). These outcomes are similar with the result of Chattha (2007) and Khan *et al*. (2003) they also noted the non-significant effect of planting spaces on the brix, SC, CJP and CCS. Moreover, trench spacing significantly influenced the total sugar yield with maximum total sugar yield was noted in 120 cm apart trenches. The maximum cane length and SCY were responsible for the maximum sugar yield in 120 cm spaced planting patterns. Previous studies of Sundara (2002) and Chattha (2007) also noted that planting patterns significantly affected the total sugar yield. Clones US-127 had maximum brix, SC, CJP, CCS and total sugar yield. The clone US-127 had minimum bagasse contents therefore, it had maximum brix, SC, CJP, and CCS as compared to other clones. Moreover, the highest cane length, SCY was responsible for the maximum sugar yield in US-127 as compared to the other cultivars. Previously, Islam *et al*. (2011) reported that cultivars differed, for brix percentage, sugar recovery and sugar yield.

Conclusions and Recommendations

In conclusion, planting in 120 cm apart trenches performed appreciably well with maximum stripped cane yield and total sugar yield as compared to other trench spacing. In the case of clones, US-272 produced maximum stripped cane yield however, US-127 produced maximum cane yield and sugar yield owing to maximum sugar recovery.

Novelty Statement

The ratooning potential of promising sugarcane clones under different trench spacing was not explored. Therefore, this study was conducted to determine the ratooning potential of different promising sugarcane clones under different trench spacing.

Author's Contribution

Riaz Ahmad: Conceived and designed the experiment.
Muhammad Aman Ullah Khan: Performed the experiment.
Muhammad Aman Ullah, Muhammad Talha Aslam and Abdul Rehman: Data collection.
Muhammad Aman Ullah and Muhammad Umair Hassan: Writing original draft.
Muhammad Nawaz, Muhammad Jahanzaib Khan, Muhammad Ahsin Ayub, Arbaz Ahmad Khan, Muhammad Adil Rehman, Bilal Ahmad Shahzad and Sajid Hussain: Reviewing and editing.

Conflict of interest

The authors have declared no conflict of interest.

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