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Research Paper

Production Potential of Ratoon Crop of Sugarcane Planted under Varying Planting Dimensions

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ABSTRACT

Ratoon crop of sugarcane is considered economical for the farming communities of Pakistan because production cost is 25 to 30% less than plant crop along with saving of seed material. A field experiment was carried out to evaluate the ratooning potential, growth, yield and quality attributes of sugarcane under different planting dimensions. The experiment was laid out in a Randomized Complete Block Design (RCBD) having three replications. The experiment comprised of the following treatments, namely: 120 cm spaced trenches, 90 cm spaced round pits having diameter of 90 cm, 60 cm spaced round pits having diameter of 90 cm, 90 cm spaced square pits having an area of 90 cm × 90 cm, 60 cm spaced square pits having area of 90 cm × 90 cm, 75 cm spaced square pits having area of 75 cm × 75 cm and 45 cm spaced square pits having an area of 75 cm × 75 cm. The plant crop of sugarcane was sown on 4th March, 2013 and harvested at 24th January, 2014; it was kept as a ratoon crop. All other agronomic practices were kept normal and uniform. The experimental results revealed that planting dimensions in ratooned cane had no significant effect on length of internodes and most of the qualitative attributes. However, planting dimensions had significant effect on the quantitative parameters like number of tillers, number of millable canes, number of internodes per cane, plant height, cane length, cane diameter, stripped cane weight, stripped and unstripped cane yield, tops and trash weights and harvest index. Statistically, highest stripped cane yield of sugarcane (102.26 t ha^{-1}) was noted at 90 cm spaced square pits having an area of 90 cm × 90 cm. Whereas, lowest stripped cane yield of sugarcane (96.15 t ha^{-1}) was obtained from 45 cm spaced square pits having an area of 75 cm × 75 cm. The experimental results indicated that 90 cm spaced square pits having an area of 90 cm × 90 cm produced the highest sugarcane yield.

Key words: Sugarcane, ratooning potential, planting dimensions.

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INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is an important sugar and cash crop cultivated in Pakistan next to cotton and rice. Cane tops are used as feed for farm animals when there is shortage of fodder (Fashihi and Malik, 1985). It contributes 3.1 and 0.6% in value added agriculture and GDP, respectively. It was cultivated on an area of 1141 thousand hectares and with production of 62.7 million tonnes (Government of Pakistan, 2015). Pakistan ranks 5th with respect to area, while it ranks 8th with regards to sugar production (FAO, 2012).

In Pakistan, conventional planting is the main cause for low sugarcane production due to less plant population, lodging, dwarf and thin cane (Ehsanullah et al., 2007; Ali et al., 2009; Ehsanullah et al., 2011). Different planting techniques affect all physiological and quantitative traits of sugarcane considerably (Bashir and Saeed, 2000).

Maximum potential can be exploited by adopting pit planting method of sugarcane since this method demonstrated a massive scope of achieving the maximum biological yield potential in various studies as compared to conventional method of planting. Pit planting of sugarcane provides applicable alternative to farmers to increase the efficiency of land, water and labor (Yadav et al., 2009).

Ratooning is a practice of growing full crop of sugarcane from sprouts of underground stubbles left in the field after harvest of the plant (main) crop. Planted sugarcane as well as, ratoons are highly exhaustive crops having higher demand for nitrogenous fertilizer due to shallow root system, decay of old roots, sprouting of stubble buds and immobilization of nitrogen. It is, therefore necessary to use 20 to 25% more nitrogenous fertilizer over the recommended dose of nitrogen for ratoon crop (Lal and Singh, 2008).

Shukla et al. (2013) reported that ratooning in sugarcane saves the cost of seedbed preparation, seed material and planting operations. However, most often ratoon crop yields are lower than the plant crop.

Malik (1997) reported that in the Punjab province, more than 50% of total sugarcane cropped area is kept as ratoon crop. Its contribution to the total cane production is about 25 to 30% (Rehman and Ehsanullah, 2008). However, more than 35% of its productivity is lost due to improper attention of the farmers towards ratoons (Malik, 1997). Naturally, the productivity of ratoon is 10 to 30% less than the plant crop of sugarcane. Low yield of ratoon crop is mainly due to low and differential ratooning potential of cultivars and sub-optimal crop management.

However, cost of production in ratoon sugarcane ranges between 25 to 30% less than the plant crop because it saves seed material cost. The main reasons for low cane yield of ratoon crop are low soil fertility, sub-optimal plant population density, poor management and improper planting methods. This necessitates the development of a suitable agro-technology for harvesting good yield of a ratoon crop. The major components of a ratoon sugarcane agro-technology are planting methods which may help in maintaining proper plant population and facilitating light and air circulation including tillage operations. Therefore, the present study was conducted to explore the production potential of ratoon crop of sugarcane planted under varying planting dimensions.

MATERIALS AND METHODS

The designed study was conducted to assess the ratooning ability of sugarcane planted at different planting dimensions conducted during 2014 to 2015 at Agronomic Research Area, University of Agriculture Faisalabad, Pakistan. Normally, the weather of this region ranges between 2 to 3°C in January and up to 48°C in June with mean annual rain fall of about 200 to 25 mm. The soil was analyzed before sprouting of the crop. To determine major physical and chemical properties of composite soil samples were taken from soil surface (0 to 30 cm) at the experimental site prior to sowing and collected samples chemically analyzed by following the standard protocols (Homer and Pratt, 1961). The soil was loamy containing sand (43.33%), silt (42.56%) and clay (14.11%) particles, having bulk density (1.33 g cm^{-3}), pH (7.7), EC (1.06 dS m^{-1}), organic matter (0.75%), available nitrogen (0.033%), available phosphorus (24 ppm), and available potassium (135 ppm).

The experiment was laid out in a Randomized Complete Block Design (RCBD) having three replications. The net plot sizes were 10.80 m × 3.60 m for treatments T_1, T_2 and T_4, 10.50 m × 3.30 m for T_3, T_5 and T_6 and 10.80 m × 3.30 m for T_7. The experiment consisted of the following treatments: T_1 = 120 cm spaced trenches, T_2 = 90 cm spaced round pits having a diameter of 90 cm, T_3 = 60 cm spaced round pits having a diameter of 90 cm, T_4 = 90 cm spaced square pits having an area of 90 cm × 90 cm, T_5 = 60 cm spaced square pits having an area of 90 cm × 90 cm, T_6 = 75 cm spaced square pits having an area of 75 cm × 75 cm and T_7 = 45 cm spaced square pits having an area of 75 cm × 75 cm.

The sugarcane variety HSF-240 was used as experimental material for this experiment. The seed rate was 75,000 double budded setts ha^{-1} to sow the last planted crop. The sugarcane was planted on 4th March, 2013. The planted crop of sugarcane was harvested at the end of January, 2014 and kept as a ratoon crop. Fertilizer was applied at 227 kg N, 150 kg P_2O_5 and 150 kg K_2O per hectare in the form of Urea, DAP and SOP, respectively. The entire P, K and 1/3rd of N were applied as a basal dose at the time of sprouting, while the remaining N was applied in two splits, 1/3rd at the start of tillering and 1/3rd before earthing up by side dressing.

Earthing up of sugarcane in T_1 was done 90 days after emergence of sprouts. A total of 16 irrigations were applied to the crop as and when needed. The amount of irrigation water received by the crop in the course of the experiment during the year was also supplemented by rainfall of about 352.3 mm. Ratoon crop was harvested manually after maturity on 20th January, 2015.

Number of millable canes in each plot was counted at harvest and then converted into number of millable canes ha^{-1}. At harvest, length of ten (10) randomly selected canes from each treatment were measured and averaged. The randomly selected ten stripped canes from each treatment were weighed together and then weight per stripped cane (kg) calculated. All unstripped canes (two trenches in each plot) were weighed (kg) before stripping and thereafter transformed to tons per hectare. All stripped canes from two trenches in each experimental unit were weighed and transformed to tons per hectare. Total brix %, commercial cane sugar (%), sucrose content in cane juice (%) and sugar recover (%) were determined by the standard procedure (Spancer and Meade, 1963). Data recorded on each parameter was tabulated and analyzed statistically by

Table 1: Effect of different planting dimensions on quantitative traits of ratooned sugarcane.

Treatments	No. of tiller m^{-2}	No. of millable canes	Plant height (cm)	No. of internodes per cane	Length of internodes (cm)	Cane length (cm)
T_1	14.0^{ab}	10.67^{b}	315^{cd}	16.67^{b}	12.89	206.93^{bc}
T_2	13.33^{b}	10.33^{b}	316^{cd}	16.63^{b}	12.56	208.83^{bc}
T_3	14.33^{ab}	11.0^{ab}	344^{b}	16.77^{b}	12.80	214.17^{b}
T_4	13.33^{b}	10.33^{b}	366^{a}	15.9^{bc}	12.86	234.67^{a}
T_5	14.67^{a}	11.67^{a}	332^{bc}	18.27^{a}	12.80	213.27^{b}
T_6	12.0^{c}	9.33^{c}	314^{cd}	16.1^{bc}	12.96	205.87^{bc}
T_7	11.67^{c}	9.0^{c}	307^{d}	15.17^{c}	12.98	196.67^{c}
LSD	1.29	0.79	19.69	1.32	NS	13.70

Table 2: Effect of different planting dimensions on quantitative traits of ratooned sugarcane.

Treatments	Cane diameter (cm)	Weight per stripped cane (kg)	Unstripped cane yield (t ha^{-1})	Stripped cane yield (t ha^{-1})	Top weight (t ha^{-1})	Trash weight (t ha^{-1})	Harvest index (%)
T_1	2.34^{b}	0.88^{bc}	118.75^{bc}	98.4^{b}	13.62^{b}	6.57^{ab}	82.87^{b}
T_2	2.31^{bc}	0.90^{bc}	119.53^{ab}	99.39^{b}	14.22^{ab}	5.92^{ab}	83.15^{ab}
T_3	2.36^{b}	0.98^{ab}	119.77^{ab}	99.68^{b}	14.74^{ab}	5.35^{ab}	83.24^{ab}
T_4	2.45^{a}	1.05^{a}	120.61^{a}	102.26^{a}	12.17^{c}	5.16^{b}	84.79^{a}
T_5	2.31^{bc}	0.88^{bc}	119.66^{ab}	99.52^{b}	14.73^{ab}	5.40^{ab}	83.17^{ab}
T_6	2.27^{bc}	0.83^{c}	118.44^{bc}	97.83^{bc}	14.18^{ab}	6.43^{ab}	82.61^{b}
T_7	2.23^{c}	0.81^{c}	117.82^{c}	96.15^{c}	15.01a	6.73^{a}	81.62^{b}
LSD	0.09	0.15	1.52	2.04	1.33	1.45	1.89

using Fisher's Analysis of Variance technique. Least significant difference (LSD) test at 5% probability level was used to compare the difference amongst treatment means (Steel et al., 1997).

RESULTS

Tables 1 and 2 showed results pertaining to various quantitative components of rationed sugarcane as influenced by planting spacing. Planting dimensions markedly improved the quantities of traits of ratooned sugarcane crop. The maximum number of tillers and number of millable canes internodes per canes were recorded in 60 cm spaced square pits having an area of 90 cm × 90 cm (Table 1), while the minimum values of these parameters were found in 45 cm spaced square pits having an area of 75 cm × 75 cm. Similarly, the plant height and cane length was found higher in 90 cm spaced square pits having an area of 90 cm × 90 cm (Table 1); however, the planting dimensions had no significant effect on the length of internodes. Moreover, it can also be seen from (Table 1) that narrow spaced planting substantially reduced the quantitative parameters of ratooned crop.

As for the cane diameter (cm), weight per stripped cane (kg), unstripped cane yield (t ha^{-1}), stripped cane yield (t ha^{-1}) and harvest index (%) of their maximum values were recorded in 90 cm spaced square pits having an area of 90 cm × 90 cm. Similarly, the minimum values of these parameters were found in 45 cm spaced square pits having an area of 75 cm × 75 cm. Trash weight indicates the vegetative growth behavior of sugarcane crop. The highest value of cane top weight (15.01) and trash weight (6.73 t/ha)was recorded at 45 cm spaced square pits having an area of 75 cm × 75 cm that was at par with all the other treatments except 90 cm spaced square pits having an area of 90 cm × 90 cm.

The effect of planting dimension was found non-significant for most of the quality parameters. The results indicated that planting dimensions had no considerable effect on brix (%), sucrose in juice (%), cane juice purity (%), commercial cane sugar (%) and cane sugar recovery (%). Although, brix percentage in cane juice was different in cane grown at various planting dimensions but this difference could not get up to the level of significance and this ranged from 21.62 to 22.11%, respectively. Table 3 showed that planting dimensions had no significant effect on commercial cane sugar. However, the commercial cane sugar ranged from 14.56 to 15.28%, respectively. Cane sugar recovery ranged between 13.69 to 14.36%; this depicts that planting dimensions failed to affect sugar recovery.

Table 3: Effect of different planting dimensions on qualitative traits of ratooned sugarcane.

Treatments	Brix (%)	Sucrose in juice (%)	Cane juice purity (%)	Cane juice (%)	Bagasse (%)	Commercial cane sugar (%)	Cane sugar recovery (%)
T_1	21.71	19.56	90.16	59.03[bc]	40.967[bc]	15.03	14.13
T_2	21.98	19.85	90.32	58.33[cd]	41.667[ab]	15.28	14.36
T_3	22.04	19.71	89.45	60.03[ab]	39.967[cd]	15.07	14.17
T_4	22.11	19.61	88.68	60.40[a]	39.600[d]	14.92	14.03
T_5	22.08	19.79	89.65	58.67[cd]	41.333[ab]	15.16	14.26
T_6	21.82	19.45	89.15	57.67[d]	42.333[a]	14.85	14.26
T_7	21.62	19.15	88.55	57.67[d]	42.333[a]	14.56	13.69
LSD	NS	NS	NS	1.34	1.34	NS	NS

T_1 = 120 cm spaced trenches, T_2 = 90 cm spaced round pits having diameter 90 cm, T_3 = 60 cm spaced round pits having diameter 90 cm, T_4 = 90 cm spaced square pits having area 90 cm × 90 cm, T_5 = 60 cm spaced square pits having area 90 cm × 90 cm, T_6 = 75 cm spaced square pits having area 75 cm × 75 cm, T_7 = 45 cm spaced square pits having area 75 cm × 75 cm.

Meanwhile, the effect of planting dimensions was found significant on cane juice and bagasse (%). The maximum value of cane juice was found highest in 90 cm spaced square pits having an area of 90 cm × 90 cm. Similarly, the highest value of bagasse was found in 45 cm spaced square pits having an area of 75 cm × 75 cm. On an average, bagasse percentage ranged between 39.6 to 42.33%, respectively, while cane juice percentage ranged between 57.66 to 60.40%, respectively under different pit dimensions.

DISCUSSION

This study investigated the influence of different planting dimensions on the quantitative and qualitative attributes of ratooned sugarcane. From the results, it clearly indicated that less spaced rows substantially reduced the quantity and quality of sugarcane crop. The highest number of tillers, number of millable canes and internodes per canes was recorded in 60 cm spaced square pits having an area of 90 cm × 90 cm (Table 1). These findings are in line with previous studies of Bashir et al. (2005) who observed that wider row spacing markedly increased the tillers count per m^2 as compared to narrow row spacing under various planting techniques.

Yadav and Kumar (2005) also reported that lesser interplant competition and wider row spacing linearly increased the millable canes. Moreover, Ali (1999) reported the maximum number of internodes per cane in pit planting as compared to flat plantation.

The plant height and cane length was found higher in 90 cm spaced square pits having an area of 90 cm × 90 cm (Table 1). The higher plant height also attributed to better conditions for growth which intercepted more radiation that ultimately produced higher plants. Similar results were reported by Cheema et al. (2002) who observed higher plant in 90 cm spaced rows as compared to 60 cm. However, these results are in contradiction with earlier findings of Shih and Gascho (1980) who found out taller sugarcane plants in 60 cm row spacing than those of 150 cm spacing. Wider spaced pits substantially improved the cane length as compared to narrow spaced pits and wider spaced pits resulted in better light penetration into the crop canopy and cross air circulation, which substantially inclined the cane length (Cheema et al., 2002). However, the length of internodes was found non-significant in all treatments. These results corroborates with the previous literature of El-Fattah et al. (1986) who reported that row spacing had no significant effect on the intermodal length.

The variability in cane diameter among pits might be due to the availability of spacing area and the level of light penetration which led to variable crop growth rate that resulted in variable cane diameter. These results are in line with previous findings of Cheema et al. (2002) and Raskar and Bhoi (2003) who recorded a linear increase in cane diameter with increasing row spacing. However, these findings are in contradiction with previous findings of Vains et al. (2000).

Planting spaces markedly improved the weight per stripped, unstripped cane yield (t ha^{-1}), stripped cane yield (t ha^{-1}) and cane top weight. However, maximum improvement was observed in 90 cm spaced square pits having an area of 90 cm × 90 as compared to other spacing. The wider spacing in sugarcane improved light penetration and circulation of air which substantially soared the photosynthetic activity, thereby resulting in more growth and yield (Vains et al., 2000; Cheema et al., 2002). Higher stripped and unstripped yield in wider spacing as compared to narrow spacing might be due to higher LAI which helped the plants to receive more radiations that ultimately increased the biomass. These results are in conformity with the findings of Bashir et al. (2005).

Differences in trash weight of sugarcane in all planting methods were ascribed to variable number of leaves, plant population and moisture percentage at maturity in leaves. Similar results were also reported by Bashir et al. (2005) and Sundara (2002). The highest value of harvest index in wider row spacing was attributed to better crop growth rate. These results are validated by Yadav and Kumar (2005) and Ahmad (2002). They observed more harvest index in crops grown at 90 cm spaced row than at 45 cm spaced rows.

The effect of planting dimension was found non-significant for most of the quality parameters. Although, brix percentage in cane juice was different in cane grown at various planting dimensions but this difference could not get up to the level of significance and this ranged from 21.62 to 22.11%, respectively. These results corroborates with the previous literature of Chattha (2007) who found non-significant effect of planting geometry on brix (%). Similarly, Khan et al. (2003) also reported non-significant effect of planting techniques on sucrose contents. In different planting dimensions, cane juice purity ranged from 88.5 to 90.32%. These results are supported by the findings of Chattha (2007) who reported that planting dimension had no marked effect on the purity of cane juice.

Meanwhile, planting dimension had no significant effect on the effect of commercial cane sugar. Moreover, cane sugar recovery ranged between 13.69 to 14.36%; this depicts that planting dimensions failed to affect sugar recovery. These results are supported by Patel et al. (1990) and Chattha (2007); they reported that planting geometry had no significant effect on cane sugar recovery. Results also revealed that planting dimension had significant effect on the cane juice content and bagasse percentage. These results are supported with the findings of Thangavelu (2004) who found a significant effect of planting techniques on cane juice percentage. On an average, bagasse percentage ranged between 39.6 to 42.33%, respectively under different pit dimensions and geometry of planting. These results are in line with those reported by Thangavelu (2004) who observed that juice extraction has positive association with bagasse weight.

Conclusion

In crux, planting dimensions substantially improved the quantitative attributes of ratooned sugarcane crop. However, the planting dimensions had no marked effect on the qualitative attributes. Moreover, maximum improvement in quantitative characters was observed at 90 cm spaced square pits having an area of 90 cm × 90 cm. Therefore, it is preferable to grow ratooned sugarcane crop in 90 cm spaced square pits having an area of 90 cm × 90 cm.

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