Research Article

Assessment of Establishing Plant's Crop Cane Portions and Setts Placement Methods on the Attributes of Sugarcane

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Abstract | The response of planting sources i.e. standing (fresh canes-frost exposed) trenched (stored canes-frost protected), cane portions and setts placement methods on the attributes of sugarcane were assessed at Sugar Crops Research Institute, Mardan-Pakistan. The experiment was conducted in RCB Design with split plot arrangement, over years (2012-13 and 2013-14). Planting sources i.e. standing (fresh canes frost exposed) trenched (stored canes frost protected) and canes portions top, middle, bottom and mixed 33 % each were assigned to main plots, while setts placement methods i.e. single, one and a half, double and triple setts 40 cm in length were allotted to sub-plots. Recommended dose of fertilizer i.e. N: 150. P_2O_5: 100. K_2O: 100 were applied and standard management practices (inter-culturing, earthing up, and irrigation) were performed. The objectives were to find best planting source, cane portions, setts placement methods and interaction for maximum emergence, visible crop stand leading to yield and yield components. Significant differences were observed among cane portions and setts placement methods for all the traits except emergence %. Planting sources exhibited significant differences for emergence percentage. The interaction of cane portions and setts placement methods were significant except for emergence percentage. Millable canes showed significant interaction for planting sources and setts placement methods. Maximum cane yield was recorded for top portion and triple setts. Millable canes excelled when top portion from standing source was planted at triple setts. Stripped cane length and yield excelled when top cane portions were planted as triple setts. Over all it was concluded that planting fresh cane top portions with double and triple setts placement methods were found better than trenched planting for cane yield and yield attributing traits.

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Introduction

Sugarcane (*Saccharum officinarum* L.) belongs to family *Gramineae* and is propagated by stem cuttings (Khan et al., 2013). It is an important cash and industrial crop of Khyber Pakhtunkhwa-Pakistan. Molasses and bagasse are the main by-products of sugar industry. During 2011-12, in Pakistan the area covered under sugarcane was 1,057 thousand hectares, producing 58,396 thousand tones with average cane yield of 55.20 tones ha^{-1}. In Khyber Pakhtunkhwa (KPK) during 2011-12, the area under sugarcane was 105.50 thousand hectares producing 4,684 thousand tones ha^{-1} with average cane yield 44.20 t ha^{-1} (Agri.

Statistics of Pak, 2011-12). In Khyber Pakhtunkhwa sugarcane is planted after frost as sole or intercropped in wheat in spring. Peshawar valley is a major sugarcane-producing zone along with Dera Ismail Khan. Severe frost inflict heavy damages to sugarcane, rendering the cane unfit for use as planting material makes buds unviable to germinate. Farmers are advised to trench sugarcane for use as planting material in spring or practice autumn plantation. The resource poor farmers of the province tend to plant cane crops at single to one and a half setts per placement. Delay in planting of cane setts reduce germination and sprouting owing to low bud moisture (Jain et al., 2009). Fresh cane setts as planting material increases germination and maximizes cane yield (Hussain et al., 2011). Selection of planting material is key factor in all-agronomic practices. Top of the stalk is relatively low in sucrose, high in reducing sugars and is of noneconomic value to the mill. The top 1/3rd portion contains, narrow internodes having alternate buds and a good supply of nutrients, which makes it valuable input as seed cane for planting. Setts taken from the top and middle portion showed better sprouting and emergence as compared to the bottom portion (Sime, 2013). Top parts of sugarcane as planting material gave promising stand establishment relative to the other planting parts, and increased cane yield (Ahmad et al., 2013). Sub-optimal setts are negatively responsible for low sugarcane yield in the country. Gap filling with fresh cane setts lowered gaps and enhanced growth and yield of plant crop (Singh et al., 2011).

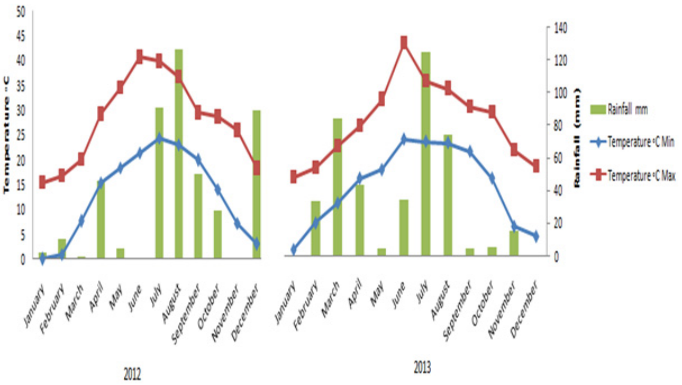

Figure 1: *Meteorological data Temperature °C and rainfall (mm) during conduction years at SCRI Mardan, located at 34° 12 N latitude and 72° 03 E longitude with altitude of 283 m*

The present study was aimed with the objectives to evaluate best planting sources, cane portions and setts placement methods for sugarcane yield.

Materials and Methods

The experimental site was Sugar Crops Research Institute (SCRI), Mardan, Pakistan, located at 34°12 N latitude and 72°03 E longitude with altitude of 283 m above the sea level. The environmental conditions are warm, subtropical climate with a mean annual rainfall of less than 348 mm (annual) at research farm. The soil is silty clay loam with soil bulk density of 1.38 g cm^{-3}. Chemical analysis revealed pH, organic matter, total nitrogen, phosphorus and potassium as 7.3, 0.55%, 370 mg kg^{-1}, 15 mg kg^{-1} and 160 mg kg^{-1}, respectively. Rainfall and seasonal temperatures (maximum and minimum) for the crop cycle are provided in Figure 1. An experiment was conducted to assess the effect of planting source, cane portions and setts placement methods on the attributes of sugarcane during 2012-13 and 2013-14. The experiment was laid out in randomized complete block (RCB) design with split plot arrangement in three replications. Plot size was 3.6 m x 4.5 m having 5 rows 90 cm apart. Sugarcane CV CP-77/400 was planted. Planting sources i.e. standing (fresh canes frost exposed, trenched i.e. (stored canes frost exposed) and cane portions [(top, middle, bottom and mixed (33 % each)] were assigned to main plots, while setts placement viz. single, one and a half, double and triple setts (40 cm in length) were allotted to sub-plots. Recommended dose of fertilizer for raising of plant crop were (added each year at 12 March) as; N, P_2O_5, and K_2O @ 150:100:100 kg ha^{-1} from Urea, DAP and SOP. Nitrogen was applied in two split doses at sowing (each year at 12 March) and at earthing up (in June). Canes were stored in trenches along with roots, tops and trash before the start of frost (in December) and roots were trimmed, trash and tops were removed (stripped) at the time of planting. Thiodon @ 2.5 liters ha^{-1} was sprayed at planting time, to control termites. Ametrin + Atrazine both @ 1.5 kg ha^{-1} were applied one month after planting for the control of weeds. Furadon @ 20 kg ha^{-1} were used against borers. Other cultural practices like inter-culturing, earthing up, and irrigation were kept uniform for all the treatment. Data were analyzed following Steel et al. (1997). Data were recorded after 30 days of plantation as described below.

Emergence (%)

Number of buds sprouted $plot^{-1}$ were recorded after 30 days of plantation.

Emergence % = Total emerged shoots out of total planted buds i.e. visible shoots/ total planted buds × 100.

Table 1: *Two year combined analysis of variance for selected traits of sugarcane as affected by planting sources, cane portions and sett placement methods during 2012-13 and 2013-14*

SOV	Df	Emergence (%)	Cane length (cm)	Millable canes (000, ha^{-1})	Cane yield (t ha^{-1})
Years (Y)	1	2.14	273.13*	29056245	27.36
Reps within Y	4	19.33	14.68	12367906	4.77
Treatments (T)	7	398.52**	833.84**	363647462**	109.67**
ST	(1)	264.73*	190.01	85037294	13.67
Cane Portion (CP)	(3)	838.00**	1879.05**	814918410**	250.83**
ST x CP	(3)	3.63	3.26	5246570	0.51
Y x T	7	25.70	15.33	10197437	2.06
Y x ST	(1)	15.29	3.80	6003356	1.44
Y x CP	(3)	11.46	6.05	1912474	1.17
Y x ST x CP	(3)	9.14	8.02	6283844	0.41
Error-1	28	64.04	135.38	45153178	7.11
SPM	3	21.21	1589.20**	6062546439**	588.32**
Y x SPM	3	10.52	10.92	3314911	0.61
ST x SPM	3	7.39	1.44	10596999*	0.19
CP x SPM	9	11.69	20.61*	55175089**	3.93**
ST x CP x SPM	9	10.45	4.28	5271267	0.17
Y x ST x SPM	3	7.16	2.03	298349	0.04
Y x CP x SPM	9	10.67	1.51	2780397	0.65
Y x ST x CP x SPM	9	11.49	4.51	1672560	0.15
Error-2	96	10.88	6.58	3474339	0.55
Total	191				

ST= *Standing (fresh canes-frost exposed) x Trenched (stored canes-frost protected);* **CP**= *Cane portions;* **SPM**= *Setts Placement Methods*

Stripped cane length (cm)

Ten randomly selected canes from each treatment were measured from bottom to the terminal point with the help of a meter rod and then averaged.

Millable canes (thousand, ha^{-1})

Millable canes refer to canes that attained normal height and thickness at physiological maturity and is ready to harvest for processing. Number of millable canes were counted in three central rows of each treatment at harvest and converted to millable canes ha^{-1}.

$$\text{Millable canes (thousand, ha}^{-1}) = \frac{\text{Uniform millable canes} \times 10{,}000\ \text{m}^2}{3\ \text{rows} \times \text{Row} - \text{Row}(.9\ \text{m}) \times \text{row length}\ (3.6\ \text{m}) = (9.72\ \text{m}^2)}$$

Stripped cane yield (t ha^{-1})

Stripped canes were weighed with the help of a scale excluding trash and tops in each treatment randomly from three central rows and converted to tones ha^{-1}.

$$\text{Stripped cane yield (t ha}^{-1}) = \frac{\text{Stripped cane yield (kg)} \times 10{,}000\ \text{m}^2}{3\ \text{rows} \times \text{Row} - \text{Row}(.9\ \text{m}) \times \text{row length}\ (3.6\ \text{m}) = (9.72\ \text{m}^2)} \times 100$$

Results and Discussion

Emergence (%)

Emergence percentage is the most essential physiological phase in the life cycle of a plant. Emergence % age were significantly ($P \leq 0.05$) affected by planting sources and cane portions (Table 1). Interactions were non-significant. Mean (Table 2) results showed that maximum emergence % age (51.2) were recorded in standing source compared to minimum (48.2) emergence percentage in trenched planting source. Mean highest emergence % age (54.3) were observed in cane top portions while lowest emergence % age (44.4) were noticed for cane bottom portion. The top and middle portion contain young buds with primordial cells which contain enzymes and easily activated during sprouting. Lower emergence % in the bottom cane portion could be attributed to growth inhibitors with aging of buds. Aged buds affects sprouting due to internal physiological condition (growth inhibitors) (Subbaro and Prasad, 2010). Cane top portion followed by middle showed better sprouting and emergence as compared to the bottom portion (Sime, 2013). Mohanthy and Nayak

(2011) recorded highest germination percentage in setts having more buds. Recommended number of setts had a significant impact on germination than lower number of setts (Patel et al., 2014). The Reduced emergence % may also be attributed to low bud moisture (Jain et al., 2009).

Table 2: *Mean emergence (% age) of sugarcane as affected by planting sources, cane portions and setts placement methods during 2012-14*

Planting Sources (PS)	Year 2012-13	Year 2013-14	Mean
Standing (S)	51.3 a	51.0 a	51.2 a
Trenched (T)	48.4 b	49.2 b	48.8 b
Significance	**	**	*
Cane Portions (CP)			
Top	54.0 a	54.6 a	54.3 a
Middle	51.2 b	51.8 b	51.5 a
Bottom	43.9 c	44.8 c	44.4 c
Mixed 33.3% each	50.3 b	49.0 b	49.7 b
LSD (0.05)	2.0	1.2	3.3
Setts Placement Methods (SPM)			
Single setts	49.3	50.1	49.7
One and half setts	48.9	49.4	49.1
Double setts	50.0	50.6	50.3
Triple setts	51.2	50.0	50.6
LSD (0.05)	-	-	-
Interaction			
ST x CP	-	-	-
ST x SPM	-	-	-
CP x SPM	-	-	-
ST x CP x SPM	-	-	-

PS= *Planting sources;* **ST**= *Standing (fresh canes-frost exposed) x Trenched (stored canes-frost protected);* **CP**= *Cane portions;* **SPM**= *Setts Placement Methods. Means for each category followed by different letters are significantly different from each other at 5% level of probability* **ns** *= non significant*

Stripped cane length (cm)

The length of a cane is directly related to final cane yield. Stripped cane length (Table 1) exhibited significant variations for cane portions and setts placement methods. Interaction CP x SPM over years were found significant. Mean (Table 3) lengthy stripped canes (221.0 cm) were observed in cane top portion with shorter (206.2 cm) stripped canes in cane bottom portion for average of both years. Average maximum (222.0 cm) cane length were recorded from triple setts with a minimum (208.4 cm) cane length in single setts over years. The increased cane length in top portion might be due to early emergence, utilized an adequate quantity of light, water and nutrients on time for their development. Favorable growing conditions have a positive impact on cane length and yield (James, 2007). Highest stripped cane length may be ascribed to better utilization of water and nutrients for growth and development of canes (Mahmood et al., 2007). The increased stripped cane length may be attributed to the inter plant competition for resources. Shukla and Menhilal (2003) recorded maximum canes lengths in three setts than one and two setts. Maximum stripped cane lengths could be achieved from 75,000 double budded setts with 90 cm spaced rows (Ehsanullah et al., 2011). The only interaction (CP x SPM) was found significant. Stripped cane lengths were increased with each level of setts enhancement and excelled when top cane portions were planted as 3 setts per placement (Figure 2).

Table 3: *Mean stripped cane lengths (cm) of sugarcane as affected by planting sources, cane portions and setts placement methods during 2012-14*

Planting Sources (PS)	Year 2012-13	Year 2013-14	Mean
Standing (S)	214.3	217.0 a	215.6
Trenched (T)	212.6	214.7 b	213.7
Significance	-	*	-
Cane Portions (CP)			
Top	220.3 a	221.7 a	221.0 a
Middle	215.6 b	218.1 b	216.9 b
Bottom	204.6 d	207.7 d	206.2 d
Mixed 33.3% each	213.2 c	215.7 c	214.5 c
LSD (0.05)	0.5	0.5	1.1
Setts Placement Methods (SPM)			
Single setts	207.7 d	209.1 d	208.4 d
One and half setts	211.1 c	213.5 c	212.3 c
Double setts	214.9 b	217.0 b	215.9 b
Triple setts	220.1 a	223.8 a	222.0 a
Lsd (0.05)	0.4	0.5	0.3
Interaction			
ST x CP	-	-	-
ST x SPM	-	-	-
CP x SPM	-	-	**
ST x CP x SPM	-	-	-

PS= *Planting sources;* **ST**= *Standing (fresh canes-frost exposed) x Trenched (stored canes-frost protected);* **CP**= *Cane portions;* **SPM**= *Setts Placement Methods. Means for each category followed by different letters are significantly different from each other at 5% level of probability* **ns** *= non significant*

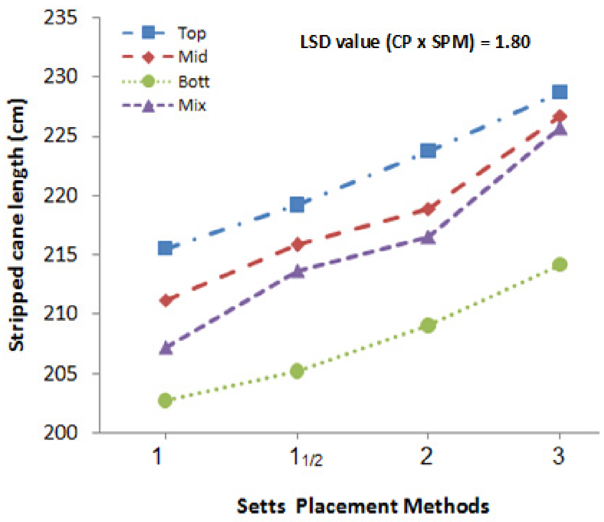

Figure 2: *Stripped cane length (cm) of sugarcane as affected by cane portions and setts placement methods*

Table 4: *Mean millable canes (thousand, ha^{-1}) of sugarcane as affected by planting sources, cane portions and setts placement methods during 2012-14*

Planting Sources (PS)	Year 2012-13	Year 2013-14	Mean
Standing (S)	89236 a	90368 a	89801
Trenched (T)	88259 b	88683 b	88471
Significance	708	1163	-
Cane Portions (CP)			
Top	93441 a	94007 a	93724 a
Middle	89789 b	90792 b	90291 b
Bottom	83204 d	84413 d	83809 c
Mixed 33.3% each	88554 c	88889 c	88722 b
LSD (0.05)	1002	1645	2810
Setts Placement Methods (SPM)			
Single setts	75720 d	77186 d	76453 d
One and half setts	83951 c	84774 c	84342 c
Double setts	92927 b	93544 b	93236 b
Triple setts	102393 a	102598 a	102495 a
LSD (0.05)	927	1217	755
Interaction			
ST x CP	-	-	-
ST x SPM	-	-	*
CP x SPM	**	**	**
ST x CP x SPM	-	-	-

PS= *Planting sources;* **ST**= *Standing (fresh canes-frost exposed) x Trenched (stored canes-frost protected);* **CP**= *Cane portions;* **SPM**= *Setts Placement Methods. Means for each category followed by different letters are significantly different from each other at 5% level of probability;* **ns** = *non significant*

Millable canes (thousand ha^{-1})

The magnitude of final cane yield is determined by millable cane count and it has a direct effect on cane yield. Significant differences (Table 1) for millable canes were exhibited by cane portions and setts placement methods. Interaction of CP x SPM and ST x SPM were found significant. Mean (Table 4) maximum millable canes (93,724 ha^{-1}) were produced from cane top portions while minimum (83,809 ha^{-1}) millable canes were observed in canes bottom portion in average of both years. Average higher millable canes (1,02,495 ha^{-1}) were recorded in triple setts compared to lower (76,453 ha^{-1}) millable canes in single setts. The enhanced number of millable canes could be attributed to early emergence and more tillers in the cane top and middle portion which counts for the final cane yield.

Millable canes are the most important component of two setts. Maximum stripped cane lengths could be achieved from 75,000 double budded setts with 90 cm spaced rows (Ehsanullah et al., 2011). The only interaction (CP x SPM) was found significant. Stripped cane lengths were increased with each level of setts enhancement and excelled when top cane portions were planted as 3 setts per placement (Figure 2). cane yield (James and Miller, 2009). Higher number of millable canes were attributed to higher germination and better tillering (Mahmood et al., 2007). Higher millable canes in double and triple setts might be due to maximum number of buds and improved germination percentage. Maximum number of millable canes in two and three budded setts than one budded setts could be due to improved germination percentage (Devi et al., 2011). Growth performance of top and middle portion of the cane is better than the bottom cane portion (Kolo et al., 2005). Normal seed rate of 100 % recommended buds with three budded setts ha^{-1} have significant impact on millable canes compared to low seed rate of recommended buds ha^{-1} (Patel et al., 2014). Planting sugarcane using 16800 three budded cane setts ha^{-1} significantly increased millable stalks m^{-2} compared to 12600 3-budded setts ha^{-1}(El-Sogheir et al., 2003). The interaction ST x SPM showed marked increase in millable canes raised from triple setts. A linear increase in millable canes was observed for planting source with setts placement methods and excelled when cane from standing plant crop was planted at triple setts. (Figure 3). The interaction (Figure 4) showed a linear increase from single to triple setts placement for all cane portions. Millable canes excelled when top portion was planted at triple setts per row followed by mid portion with the same cane planting method.

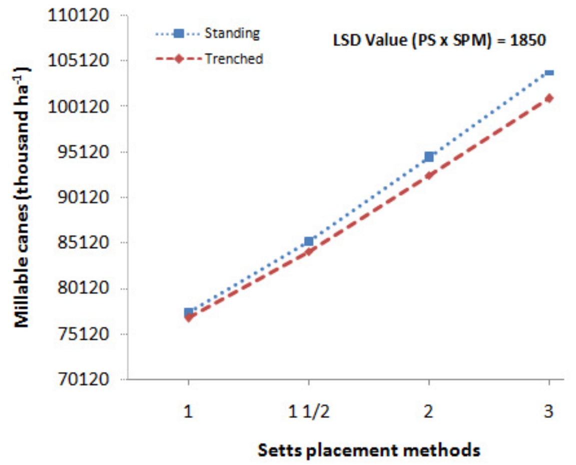

Figure 3: *Mean millable canes (thousand, ha-1) of sugarcane as affected by planting sources and setts placement methods.*

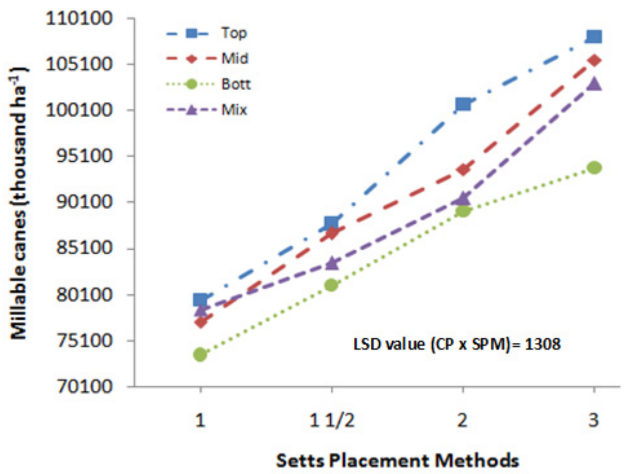

Figure 4: *Mean millable canes (thousand, ha-1) of sugarcane as affected by cane portions and setts placement methods*

Stripped cane yield (t ha-1)

The final cane yield is a function of integrated interplay of various yield components. Stripped cane yield (Table 5) showed significant variations for cane portions and setts placement methods. Interaction CP x SPM were found significant over years. Cane portions have significantly boost up stripped cane yield. Average maximum (72.4 t ha-1) cane yield was obtained from cane top portion followed by (66.9 t ha-1) cane yield from cane bottom portions. Mean higher (73.3 t ha-1) cane yield was noticed in triple setts than lower (65.2 t ha-1) cane yield in single setts placement methods. High cane yield could be due to short internodes, maximum number of buds, higher germination percentage and increased millable canes in the top cane portion. High cane yield could be attributed to improved germination percentage and increased number of millable canes in two and three budded setts (Devi et al., 2011). Significant effect of millable canes on

Table 5: *Mean stripped cane yield (t ha-1) of sugarcane as influenced by planting sources, cane portions and setts placement methods during 2012-14*

Planting Sources (PS)	Year 2012-13	Year 2013-14	Mean
Standing (S)	69.8	70.7 a	70.3
Trenched (T)	69.4	70.0 b	69.7
Significance	-	*	-
Cane Portions (CP)			
Top	72.0 a	72.9 a	72.4 a
Middle	70.1 b	70.8 b	70.5 b
Bottom	66.4 c	67.4 c	66.9 c
Mixed 33.3% each	70.0 b	70.3 b	70.2 b
LSD (0.05)	0.5	0.5	1.1
Setts Placement Methods (SPM)			
Single setts	65.0 d	65.5 d	65.2 d
One and half setts	69.4 c	70.0 c	69.7 c
Double setts	71.4 b	72.2 b	71.8 b
Triple setts	72.7 a	73.8 a	73.3 a
LSD (0.05)	0.4	0.5	0.3
Interaction			
ST x CP	-	-	-
ST x SPM	-	-	-
CP x SPM	**	**	**
ST x CP x SPM	-	-	-

PS= *Planting sources;* **ST**= *Standing (fresh canes-frost exposed) x Trenched (stored canes-frost protected);* **CP**= *Cane portions;* **SPM**= *Setts Placement Methods. Means for each category followed by different letters are significantly different from each other at 5% level of probability* **ns** *= non significant; LSD value (CP X SPM)= 0.52*

cane yield might be due to high population density (Mohanthy and Nayak, 2011). Hussain et al. (2011) recommended fresh setts for maximum cane yield over stale cane setts. On contrary, Bell et al. (2004) reported that high density planting causing undesirable effects like lodging which reduce stalk size, stalk weight and cane yield. For maximum cane yield 100% recommended three setts ha-1 is needed over lower number of setts of 75% recommended single setts ha-1 (Patel et al., 2014). Singels et al. (2009) observed 21% stalk yield increased as per meter reduction in row spacing occurred. Significantly higher stripped cane yield was observed in 90 cm row spacing among four planting geometries (Chakrawal and Kumar, 2014). The interaction, CP x SPM observed significant (77.0 t ha-1) for stripped cane yield in cane top portions triple setts placement with (62.9 t ha-1) stripped cane yield in cane bottom portion single setts placement.

Stripped cane yield excelled when top portion were planted at triple setts per unit placement followed by the same cane portions planted at double setts per unit placement (Figure 5).

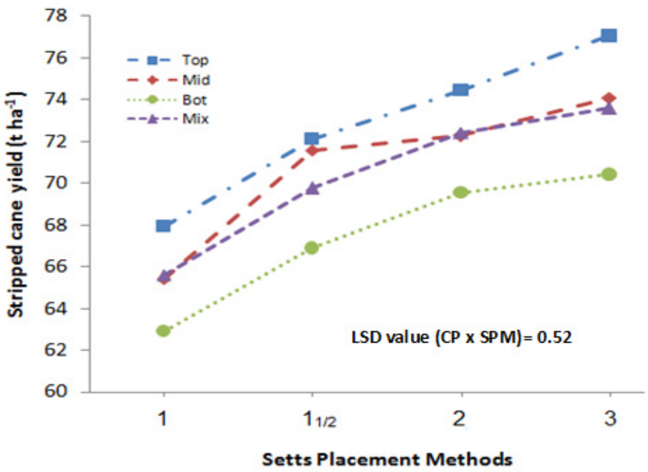

Figure 5: *Stripped cane yield (t ha^{-1}) of sugarcane as affected by cane portions and setts placement methods.*

Conclusions

Over all it can be concluded that planting fresh plant's top portions, obtained from plant crop, with double and triple setts placement were found best for yield and yield attributing traits. However, triple setts placement increased cane yield at increasing setts costs (Data excluded).

Acknowledgments

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Authors' Contribution

Shahid Ali was the main investigator of the research work carried out in this study. Dr. Habib Akbar was the an advisor. Mohammad Tariq Jan helped in research (especially statistical analysis) work, while Mohammad Jamal Khan assisted in making first draft of the manuscript and Abdul Bari provided a helping hand in data collection at Research Institute.

Conflict of Interest

The author(s) declare(s) that there is no conflict of interests regarding the publication of this article.

References

- Agri. Statistics of Pakistan. 2011-12: Govt. of Pakistan. Ministry of National Food Security and Research (Economic Wing), Islamabad.
- Ahmad, M., K.P. Baiyeri and B.C. Echezona. 2013. Effect of planting parts and potassium rate on the productivity of sugarcane (*Saccharum officinarum* L.). Expl. Agri. Horti., 2(1): 23-30.
- Bell, M.J., A.L. Garside, N.V. Halpin and J.E. Berthelesen. 2004. Interactions between stalk number and stalk weight and the implications for cane yield. Proc. Aust. Soc. Sugarcane. Technologist. 26.
- Chakrawal, D., and N. Kumar. 2014. Response of sugarcane (*Saccharum spp. hybrid* complex) varieties to various planting geometry. Indian. Journal Agronomy. 59(2): 341-343.
- Devi, T.C., M. Bharathalakshmi, V. Gouri, M.B.G.S. Kumari, N.V. Naidu and K.P. Rao. 2011. Studies on the effect of sett size, seed rate and sett treatment on yield and quality of sugarcane. Indian Journal of Sugarcane Technology. 26(2): 4-6.
- Ehsanullah, K.M. Jabran, Jamil and A. Ghafar. 2011. Optimizing the row spacing and seeding density to improve yield and quality of sugarcane. Crop & Environment. 2(1): 1-5.
- El-Sogheir, K.S., and A.M. Mohamed. 2003. Optimal seed rate for some promising sugarcane varieties. Egyptian. J. Agric. Res. 81(4): 1693-1705.
- Shukla, S.K., and Menhilal. 2003. Effect of sett size, planting method and soil-moisture regime on growth and yield of sugarcane. Indian. J. Agric. Sci. 73(10): 534-537.
- Hussain, F., M.A. Sarwar, S. Ahmad, M.A. Ali, N. Fiaz and A.A. Chatta. 2011. Effect of stale and fresh cane setts (seed) on yield and quality of sugarcane (*Saccharum officinarum L*). Int. J. Agric. Appl. Sci. 3(1): 35-37.
- Jain, R., S. Solomon, A.K. Shrivastava, P. Singh, C.P. Prajapati, R.K. Singh and P. Lal. 2009. Impact of harvest to planting delays on the sprouting of seed cane. Sugar Tech. 11(2): 231-233. http://dx.doi.org/10.1007/s12355-009-0040-6
- James, N.J., and J.D. Miller. 2009. Selection in two seedlings of four sugarcane progenies. Crop science. 11(6): 245-248.
- James, N.J. 2007. Yield components in random and selected sugarcane varieties. Crop science.,

11(6): 245-248.
- Khan, I. A., S. Bibi, S. Yasmin, A. Khatri and N. Seema. 2013. Phenotypic and genotypic diversity investigations in sugarcane for drought tolerance and sucrose content. Pakakistan Journal of Botony 45(2): 359-366.
- Kolo, I.N., A.A. Adesiyun, S.M. Misari and M.N. Ishaq. 2005. Evaluation of top, middle and bottom stalk of sugarcane as planting material. Sugar Technology 7(2-3): 89-92. http://dx.doi.org/10.1007/BF02942539
- Mahmood, A., M. Ishfaq, J. Iqbal and M.S. Nazar. 2007. Agronomic performance and juice quality of autumn planted sugarcane (*Saccharum officinarum* L.). Int. J. Agric. Biol. 9 (1): 167-169.
- Mohanthy, M., and P K. Nayak. 2011. Economizing seed cane quantity by reducing sett size and bud number with sett treatment in sugarcane cultivation. Indian Journal of Sugarcane Technology. 26(2): 59-60.
- Patel, D., and R. Patel. 2014. Influence of sett size, seed rate and sett treatment on yield and quality of sugarcane. Bioscan. International Journal of Life Science 9(1): 55-57.
- Sime, M. 2013. The effect of different cane portions on sprouting, growth and yield of sugarcane (*Saccharum spp. L.*). Intl. J. Scientific & Res. Publication. 3(1): 1-3.
- Singh, S. N., D.V. Yadav, T. Singh and G.K. Singh. 2011. Optimizing plant population density for enhancing yield of ratoon sugarcane (*Saccharum officinarum* L.) in sub-tropical climatic conditions. Indian. J. Agric. Sci. 81(6): 571-574.
- Singels, A., and M.A Smit. 2009. Sugarcane response to row spacing-induced competition for light. Field. Crops. Res. 113: 149-155. http://dx.doi.org/10.1016/j.fcr.2009.04.015
- Steel, R.G.D. J.H. Torrie, D.A. Dickey. 1997: Principles and procedures of statistics. A biometrical approach. 3rd edn. pp. 400-428 McGraw Hill Book Co. Inc, New York.
- Subbaro, M.S., and R.B. Prasad. 2010. Studies in India on the germination of sugarcane. Indian Journal of Plant Physiology, 3(2): 181-194.