Research Article

Effect of Planting Sources, Cane Portions and Setts Placement Methods on Sugarcane Yield Attributing Traits

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Abstract | This experiment was performed to find out the best sugarcane plantation source between trenched and fresh stocks, efficient method of setts placement, selection of paramount cane portions and the interaction of yield and yield components. The effect of planting sources (i.e. sugarcane fresh seed and the one obtained from stock buried underground), cane portions and setts placement methods on sugarcane yield attributing traits were examined at Sugar Crops Research Institute (SCRI), Mardan, Khyber Pakhtunkhwa Pakistan. The experiment was conducted in RCB Design with split plot arrangements, in 3 replications for two years (2012-14). Different planting material i.e., trenched (sugarcane buried in soil to avoid frost damage) and fresh cane (directly obtained after harvesting of standing crop) stalk segments i.e. upper, middle, lower and 33 % (having upper + middle + lower cane portions in uniform proportion of 33) each mixed portions of cane were allotted to the main plots, whereas sub plots were given to methods of setts placement (single, one and half, double and three setts (sugarcane stem portion with three buds) each 40 cm. Fertilizer was applied as N: 150 P_2O_5: 100 K_2O: 100 at sowing and earthing up from Urea, DAP and SOP sources. Uniform management practices were performed. All traits showed significant ($p \leq 0.05$) differences for planting sources, cane portions and setts placement methods. Interaction of cane portions and setts placement methods were significant for emerged shoots, tillers, plant height and biological yield. Results revealed higher ($p \leq 0.05$) emerged shoots and tillers in canes planted from standing source (sugarcane standing crop) top portion with triple setts. This was also found that tallest plants with maximum biological yield were recorded in canes top portion with triple setts placement methods. Minimum results were observed for all the traits when bottom portion from trenched planting source was planted at single setts. Study suggests that planting fresh cane top portions with double and triple setts placement methods are better than trenched planting for cane yield and yield attributing traits.

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Keywords | Planting sources, Cane portions, Setts placement methods, Tillers, Plant height biological yield

Introduction

Sugarcane (*Saccharum officinarum* L.) belongs to family *Gramineae* which is spread by stalk portions (Khan *et al.*, 2013). It is believed to be the most important cash and sugar crop of the country, Pakistan (Deho *et al.*, 2002). The main by-products of sugar industry are molasses and bagasse. The area under sugarcane crop, during 2013-14, in Pakistan was 1,172.5 (000 ha), with a produce of 67,460.1

(000 tones) yielding 57.5 tones ha^{-1} (Agri. Statistics of Pak, 2013-14). During 2013-14 the sugarcane area in KPK (Khyber Pakhtunkhwa Province) was 117.38 (000 ha) with a yield of 5361.4 (000 tones ha^{-1}) and an average cane yield at the rate of 45.67 t ha^{-1} (Agri. Statistics of Pak, 2013-14). The low cane yield in Pakistan is attributed to many factors. Selection of proper planting material, may negatively affect seed cane plantation as Deren *et al.* (1990) stated that delayed planted seed cane gave 20% less cane yield than freshly planted cane in the plant cane crop and a loss of 3,000 kg of sugar ha^{-1}, on account of dehydration in delayed planted seed cane. Similarly, delay in planting of seed cane reduce germination and sprouting owing to low bud moisture (Jain *et al.*, 2009). In addition, a decreasing trend was observed in germination, tillering, sugar yield and cane yield for stale cane compared to fresh seed setts. Also in stale seed germination percentage observed was 13.95 %, 21.72 %, 33.13 %, 42.56 %, while tillering 3.77%, 6.60%, 10.38 %, 13.20 % and cane yield 9.75 %, 19.2 % 3,34.75 %, 44.55 % respectively as compared to fresh seed setts, however, fresh seed setts usage ultimately quicken rate of germination, enhances tillering capacity and maximize the cane yield (Hussain *et al.*, 2011). Likewise, sub-optimal number of setts placement can also cause decrease in cane yield. Lack of setts placement methods may decline sugar cane yield in Pakistan (Ameen *et al.*, 2014) while germination percentage of three budded setts is higher than setts having > or ≤ than 3-buds. Moreover, the middle bud of a 3-budded sett has the highest germinating capacity followed by top end bud and the bottom end bud respectively. Also the middle bud have nodes on either side, its moisture resources are better protected than those of terminal buds. Similarly, the germination capacity of single bud sett is very poor owing to loss of moisture from cut ends on either side. Patel and Patel (2014) reported that normal seed rate of 100 % quantity recommended buds ha^{-1} had a significant impact on germination, number of millable canes, cane yield (commercial cane sugar) as compared to lower seed rate of 75 % recommended buds ha^{-1}. They concluded that two and three budded setts gave higher cane yield than single budded setts. If whole cane stalk is planted without being cut into setts, usually few buds at top end germinate and the lower end buds remain inactive due to top dominance polarity (missing, buds gaps). The effect of top dominance is eliminated when cane stalk is cut into pieces. Moreover, two other factors i.e. sub-optimal number of setts placement and occurrence of severe frost in winter also have negative effects on seed cane plantation. Low seed rate is the most limiting factor for decreased yield in Pakistan (Naeem *et al.*, 2007). Bottom portion of sugarcane results in lower germination and emergence than top and middle segments when used as planting material (Sime, 2013).

Several factors contribute to the stand establishment and cane yield. For instance, the sugarcane fresh segments resulted in better crop stand and yield as compared to other planting sources e.g. sugarcane stock obtained from trench or stored aboveground under proper sheds) (Ahmad *et al.*, 2013). Moreover, the gaps in sugarcane crop usually are the result of using seed with damaged buds, more elongated internodes and pest infestation. The growth and yield of plant crop was enhanced by planting fresh setts and thereby filling the left gap (Singh *et al.*, 2011). The present study was aimed to evaluate best source of planting, cane segments and methods of setts placement for cane yield and yield attributing traits.

Materials and Methods

Experiment on "Effect of planting sources, cane portions and setts placement methods on sugarcane yield attributing traits" was conducted on sugarcane plant crop at SCRI Mardan (Sugar Crops Research Institute) Khyber Pakhtunkhwa Province of Pakistan over years during 2012-14 (each experiment was planted on 12th March) using RCB design with split plot in three repeats. First experiment was conducted on sugarcane plant crop and the second experiment on the ratoon obtained from the same crop. The size of each plot was 3.6 m x 4.5 m with 5 rows and 90 cm length. The soil textural class was clay loam.

Sugarcane variety CP-77/400 was planted in this experiment. Different sources of planting i.e. trenched (sugarcane seed which was stored underground in trench 5 feet deep, 8x5 feet (length x width)) and fresh cane (obtained from sugarcane standing crop) stalk segments upper, middle, lower portions @ 33 % (i.e. having these three portions in equal percentage of 33) were allotted to main plots, whereas methods of setts (sugarcane portion with three buds) placement were given to the sub plots. Fertilizer dose of NPK at the rate 150:100:100 kg ha^{-1} was applied on 12th March 2012 and 2013 using Urea, DAP and SOP as sources. Nitrogen was applied in two split doses at planting (12th March) and at earthing up in June. Sugarcane stalks with trash, tops and roots were placed in trenches before the onset of frost (December). At planting time, the roots along with tops and trash (dried sugarcane leaves) were stripped (removed).

Uniform cultural practices were applied to all the experimental treatments. Data were recorded on selected traits and analyzed following (Steel *et al*., 1997).

Emerged shoots were noted in each treatment after 30 days of plantation and then converted to emerged shoots ha^{-1}. Tillers/Culm m^{-2} were recorded by counting the number of tillers (shoots) randomly at 3 spots each in three central rows after two months of plantation and then averaged. i.e., $3\times1\times0.9 = 2.7$ m^2. Biological yield was measured by selecting ten randomly selected stalks from each treatment. The stalks were tagged and then measured from the soil surface to the top node dewlap of the plant at the time of harvest with the help of meter rod and then averaged. All unstripped stalks (stalks along with tops and trash) of the three central rows were weighed with the help of scale before stripping trash and removing the tops and converted to tones ha^{-1}.

$$\text{Biological yield } (t\,ha^{-1}) = \frac{\text{Biological yield in kg x } 10{,}000\ m^2}{3 \text{ rows x R} - \text{R}(.9m) \text{ x row length}(3.6m)\ =\ (9.72\ m2)} \times 1000$$

Results and Discussion

Emergence is believed to be the most vital phase in the life cycle of any plant. Emerged shoots per hectare were significantly ($P \leq 0.05$) affected by planting sources, cane portions and setts placement methods (Table 1). Mean results showed that maximum emerged shoots (82864) were recorded in standing source as compared to minimum (78691) emerged shoots in trenched planting source. Mean higher emerged shoots (90972) were observed in cane top portions while lower emerged shoots (72518) were noticed for cane bottom portion (Figure 1). The results for triple placed setts revealed a maximum average emerged shoots of 125270 while single placed setts data showed a minimum shoots emergence of 44894 only (Figure 1). The top and middle portions of sugarcane contain cells of primordial nature. These cells have enzymes and thus activated during sprouting. Lower emerged shoots at lower cane segments may be attributed to growth inhibitors with age factor of the buds. Aged buds affects sprouting due to internal physiological condition (growth inhibitors) (Subbaro and Prasad, 2010). Cane top portion followed by middle revealed comparatively high sprouting and emerged shoots when compared with the lower cane portion (Sime, 2013) which are in agreement with the current study. Greater shoot population might be due to the better germination of planted buds. Bashir *et al.* (2000) observed that positive relationship between seeding density and emerged shoots of sugarcane. Mohanthy and Nayak (2011) recorded that highest germination percentage in setts having more buds. Recommended number of setts had a momentous effect on the germination than comparatively lesser placed setts (Patel and Patel, 2014). The reduced emerged shoots may also be attributed to lower moisture content in bud (Jain *et al*., 2009). The data for interaction effect (CP x SPM) gave emerged shoots ha^{-1} from the top cane segments under the triple placed setts, while the single placed setts method revealed sub-optimum emergence of shoots ha^{-1} for the lower cane segments.

Table 1: *Emerged shoots (ha^{-1}) and tillers (m^{-2}) of sugarcane as affected by planting sources, cane segments and methods of setts placement during 2012-14.*

Planting Ssources (PS)	Emerged shoots (ha^{-1})	Tillers (m^{-2})
Standing (S)	82864 a	26.8 a
Trenched (T)	78691 b	25.3 b
Significance	**	*
Cane segments (CS)		
Top	90972 a	29.1 a
Middle	82176 b	26.8 b
Bottom	72518 d	23.2 c
Mixed 33.3% each	77443 c	25.1 b
LSD (0.05)	3417	2.1
Methods of setts placement (MSP)		
Single setts	44894 d	16.1 d
One and half setts	64313 b	23.1 c
Double setts	88632 c	31.7 b
Triple setts	125270a	33.9 a
LSD (0.05)	962	0.53
Interaction		
ST x CS	-	-
ST x MSP	-	-
CS x MSP	**	**
ST x CS x MSP	-	-

Means for each category followed by different letters are significantly different from each other at 5% level of probability ns: non-significant.

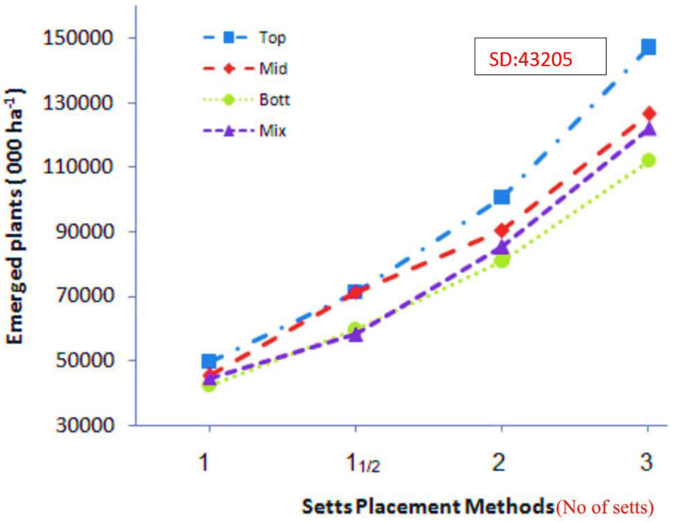

Figure 1: *Emerged shoots (ha^{-1}) of sugar cane as affected by cane segments and methods of setts placement.*

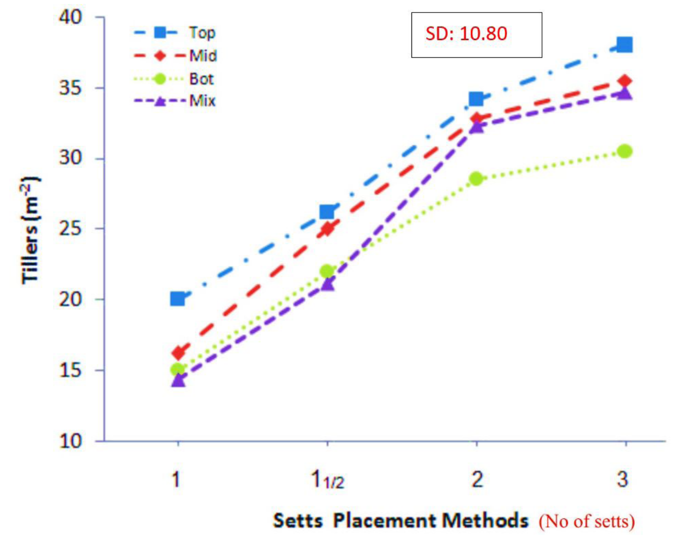

Figure 2: *Tillers (m^{-2}) of sugar cane as effected by cane segments and methods of setts placement.*

Tillering is referred to the process by which the branches are produced from the underground short joints of stem. As a matter of fact, the shoots are also produced on the stem; hence, tillering plays a pivotal role in final yield of sugarcane. Data given in Table 1 showed that cane portions, planting sources and methods of setts placement had significantly variated tillers m^{-2}. Average tillers 26.8 and 25.3 m^{-2} were recorded for fresh and trench method of planting sources. Sugarcane upper segments revealed significantly high number of tillers (29.1 m^{-2}) as compared to the cane lower segments with (23.2 m^{-2}) number of tillers. Maximum tillers of 33.9 m^{-2} were observed in triple setts with minimum (16.1 m^{-2}) tillers in which single setts were placed. The interactive effect of (CP x SPM) was found significant as for as tillers m^{-2} are concerned. The highest number of tillers was observed in the triple placed setts of the upper cane segments followed by the double placed setts methods while the single setts showed the lowest number of tillers from bottom and mix cane portions respectively (Figure 2). Highest tillering could be attributed to maximum germination percentage. Ali *et al.* (1999) noted that highest tillering were due to highest germination. Mohanthy and Nayak (2011) found highest germination percentage and tillers in setts having more buds. Recommended number of setts had a significant impact on germination and number of tillers than lower number of setts (Patel and Patel, 2014).

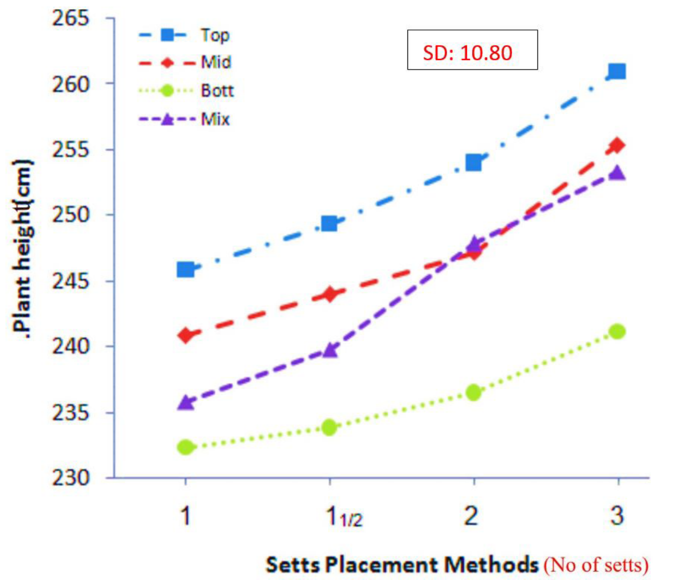

Figure 3: *Plant height (cm) of sugar cane as affected by cane segments and methods of setts placement.*

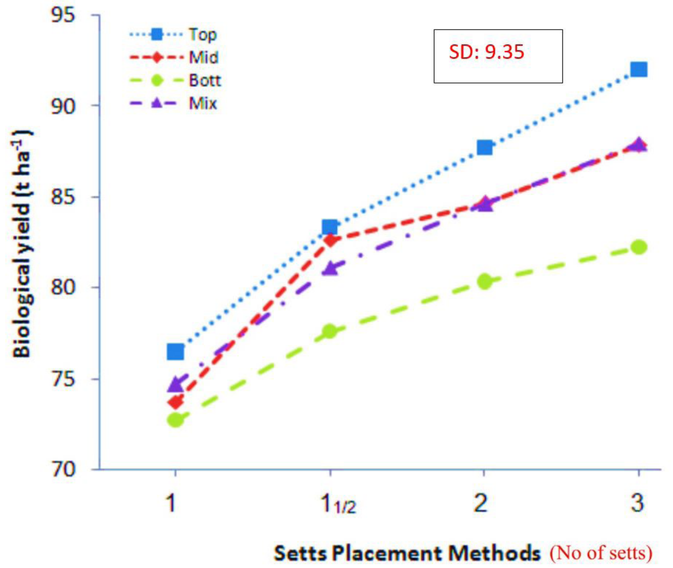

Figure 4: *Biological yield (t ha^{-1}) of sugar cane as affected by cane segments and methods of setts placement.*

Plant height is a combination of better crop growing conditions and varietal characteristics. It contributes enormously to increase crop biomass. Sugarcane segments and methods of setts placement had a significant effect on plant height as shown in Table 2. Mean maximum taller plants (251.2 cm) were observed in upper cane segments while the lowest plant height of 234.6 cm was found in lower cane segments. This may be attributed to rapid sprouting of the buds of upper and middle portion in comparison with the lower portion. Worku (1992) found that upper segments of sugarcane give optimum germination and requires short time for sprouting than lower portion. Highest plant height might be ascribed to better utilization of water and nutrients for growth and development of canes (Mahmood *et al*., 2007). Average higher plant height of 251.4 cm was found in triple placed setts when compared with the lower plant height of 237.9 cm under the single placed setts. The inter or intra competition of plants for water, light, and absorption of nutrients becomes sufficiently high thereby affecting plant height. Maximum cane length was recorded in three sets than one and two sets (Shukla and Menhilal, 2003). Sugarcane plant height can be significantly affected by the different methods of setts placement (Somoro *et al*., 2009). The interaction effect of cane segments and method of setts placement showed that plant height was maximum in triple placed setts having cane upper segments as compared to least plant height in single setts placement (Figure 3).

The data in Table 2 revealed that biological yield was affected significantly by cane stalk segments and methods of setts placement. The average maximum biological yield of 84.4 tonnes ha^{-1} were noted for cane top portions while average lower (77.5 tonnes ha^{-1}) biological yield recorded in cane lower portion. Mean high biological yield of 86.7 tonnes ha^{-1} was recorded for plants under triple placed setts when compared with the lower biological yield of 74.2 t ha^{-1} in single setts placement. The data for the interaction effect of CP x SPM revealed that biological yield has been significantly affected over the years. Higher biological yield was found in cane upper segment of triple placed setts. Increased biological yield could be due to short internodes, maximum number of buds and higher germination percentage in cane top portion (Figure 4). Devi *et al*. (2011) attributed that high biological yield to improved germination percentage in two and three budded setts. Mohanthy and Nayak (2011) found a significant effect of high population density on biological yield. Hussain *et al*. (2011) recommended that fresh cane setts over stale cane setts for maximum biological and cane yield. Sakaigaichi *et al*. (2010) recorded higher number of cane stalks, maximum fresh and dry-matter yields in dense planting in both years which could be attributed to different absorption of solar radiation. The reduction per meter row spacing increased the biomass by 22% on average (Singles and Smit, 2009). The plant maturity, cultivar and annual climate induce variation in the biomass of sugar cane crop. The lower solar radiation in first year significantly lowered the tones of canes ha^{-1} (TCH) as compared to the second year (Gilbert *et al*., 2004).

Table 2: *Plant height and biological yield of sugarcane as affected by planting sources, cane segments and methods of setts placement during 2012-14.*

Planting Sources (PS)	Plant height (cm)	Biological yield (t ha^{-1})
Standing (S)	244.9	81.75
Trenched (T)	242.6	81.02
Significance	ns	ns
Cane Segments (CS)		
Top	251.2 a	84.4 a
Middle	245.7 b	81.9 b
Bottom	234.6 c	77.5 c
Mixed 33.3% each	243.6 d	81.7 b
LSD (0.05)	5.3	1.08
Methods of Setts Placement (MSP)		
Single setts	237.9 d	74.2 d
One and half setts	240.7 c	80.8 c
Double setts	245.0 b	83.8 b
Triple setts	251.4 a	86.7 a
LSD (0.05)	1.0	0.31
Interaction		
ST x CS	-	-
ST x MSP	-	-
CS x MSP	**	**
ST x CS x MSP	-	-

Means for each category followed by different letters are significantly different from each other at 5% level of probability ns= non significant.

Conclusions and Recommendations

The overall experiment can be concluded that plantation of fresh plant's upper cane 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).

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Novelty Statement

The study iss unique as it also addressed the different sowing patterns of sugarcane combined with use of different plant portions for improved crop production. In addition, it also helped determine the impact of all these activities on sugarcane crop production.

Author's Contribution

Shahid Ali did the field experiment and collected data. Habib Akbar conceived the idea. Shamsher Ali did statistical analysis of the data. Adnan Nasim helped him in writing of the article. Muhammad Ismail did proof reading of the article. Nur Ul Haq and Muhammad Usman both helped in data collection.

Conflict of interest

The authors have declared no conflict of interest.

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