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Influence of Stale Cane Seed on Productivity of Sugarcane in Semi-Arid Climate

Naeem Ahmad[1], Mahmood-Ul-Hassan[1*], Muhammad Akhlaq Mudassar[1], Muhammad Shahzad Afzal[1], Abdul Khaliq[1], Hafiz Basheer Ahmad[1], Salma Niaz[1], Mubashra Yasin[1] and Wardah Muzaffar[2]

[1]Sugarcane Research Institute (SRI), Ayub Agricultural Research Institute (AARI), Faisalabad, Punjab 38850, Pakistan.
[2]Groundnut Research Station, Attock, Punjab 43600, Pakistan
*Corresponding Author: Dr. Mahmood-Ul-Hassan
E-mail: muh.agr@gmail.com

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Abstract

Sugarcane is an important sugar crop grown under diverse environmental conditions in Pakistan. This study was conducted to evaluate the comparative effect of sugarcane seed having different harvesting or stalling period on productivity of sugarcane. The experiment was laid out in randomized complete block design with split plot arrangement for two consecutive years. Three commercial sugarcane varieties *viz.* CPF 248, CPF 247 and CPF 246 were kept in main plots whereas cane setts staling; fresh, 3 days, 6 days & 9 days old stale cane setts were placed in sub-plots. Standard procedure was followed for recording all observations. Fisher's analysis of variance technique by using Statistix 8.1 was used to analyzed data and least significant difference test was employed to compare treatment means at 5% probability level. Graphs were drawn through Microsoft Excel and SigmaPlot. The data revealed that sugarcane clones were differed significantly for most of biometric traits under study except cane yield whereas impact of cane setts stalling was also significant except sugar contents. The interactive effect of all treatment combinations for sugarcane clones and cane setts stalling was found significant except for commercial cane sugar (CCS%). It was found that clone CPF 247 exhibited highest cane and sugar yield by planting fresh cane setts as against lowest for CPF 248 when planted with 9 days old stale cane setts during both years of experimentation. Better growth and yield related traits were predominantly attributed to planting of fresh cane seed having better germination, tillering and cane density

Keywords: Sugarcane, stale cane seed, cane yield, sugar contents, sugar yield

Introduction

Sugarcane *(Saccharum officinarum* L.) is an important cash crop of Pakistan that plays a pivotal role in boosting economic status of growers and country's economy in terms of food security and employment. It provides basic raw material for sugar industry. In Pakistan, sugarcane has a 0.8 percent share in GDP and contributes 3.7 percent in agriculture value addition. It is cultivated on about 1260 thousand hectares with production of 88.6 million tons of canes by averaging 70.3 (TCH) (Govt. of Pakistan, 2022). Sugarcane is propagated by stalks (Yadav, 1991), also known as billets or setts. Due to vegetative propagation, health and vigor of cane setts or billets (cane seed) is of great importance and is directly affected by freshness or staleness of cane cuttings. Sugarcane planting might be delayed due to many reasons such as unavailability or shortage of labor and other inputs, unfavorable weather condition, over-cutting of seed, transportation problems and distant planting site etc. Apart from these, many intermediary processes during harvesting-to-planting, like cutting of sett (manual/mechanical), striping, storage, transportation, chemical treatment, placement in furrows, soil covering etc. are also not only cause physical damage to buds of cane setts but also promotes staleness of seed-cane (Jain *et al*., 2009). Delay in planting and crushing of fresh cane after cutting can cause decrease in sucrose content, purity, stalk weight (Shrivastava *et al*., 2008; Liu *et al*., 2009), increase in reducing sugar (Deng *et al*., 2002) and fiber content (Qi & Jiang, 2006; Jiang, 2007) which leads to tremendous losses to both farmers and sugar mills. Moreover, the reduction in germination from staled cane-setts compared with using fresh seed-setts (Shrivastava *et al*., 2008; Liu *et al*., 2009) has an adverse impact on the crop. Aslam *et al*., (2001) reported that setts delayed for more than 16 hours are not considered good to plant. It is apparent that planting material has substantial influence on sprouting of sugarcane (Barnes, 1974). Thus, the selection of proper and suitable planting material is most important factor among various agronomic practices which require due attention in sugarcane agriculture. Age of the seed material, portion of a stalk, number of buds per sett, nutritional status of seed cane, duration between cutting and planting are known to have considerable effect on sprouting and subsequent growth of sugarcane (Barnes, 1974; Worku, 1992). Stalling impacts moisture of bud-sett and nutrients like sucrose and reducing sugar contents of seed cane/setts. With increase in stalling time, bud & sett moisture and sucrose percentage of juice decreases whereas total soluble solids and reducing sugars increases. Germination percentage and fresh weight of cane seeds decreased with increasing stalling time (Shrivastava *et al*., 2008). Aging of buds also attributes to lower percentage of sprouting in the bottom portion (Worku, 1992; Das,

2005). Research findings in other countries also revealed that in aging buds the internal physiological conditions are liable to undergo changes affecting sprouting (Subbaro and Prasad, 2010). It is believed that aging of cane seed could cause internal change like accumulation of growth inhibitors (Das, 2005), metabolic and enzymatic depletion of essential food reserves, denaturation of proteins, damaging to synthesizingability and increasing sensitivity to stress conditions and field pathogens (Sime, 2013). In view of the huge expenditure on cane growing particularly cost of seed sett/billet and its preparation, this circumstance could inflict a great financial loss on the sugar estate. Therefore, sufficient reliable information is needed to identify the effect of time gap between seed cane cutting and planting on productivity of sugarcane. Therefore, this study was conducted to determine maximum possible cutting–planting duration of cane seed without losing germination potential and other biometric traits of sugarcane.

Materials and Methods

Experimental Location: The experiment was conducted at Sugarcane Research Institute (SRI), Faisalabad, Pakistan located at Latitude of 31° 25' N and Longitude of 73° 09' E for two consecutive crop seasons, 2011-12 and 2012-13. During both years, physico-chemical analysis for soil of experimental site was carried out before planting of crop by taking composite soil samples from depth of 15-30 cm. The soil analysis was conducted at Soil and Water Testing Laboratory, Ayub Agricultural Research Institute (AARI), Faisalabad and results are shown in Table 1. The climatic data for study duration of experimental site for both crop years is given as Figure 1.

Table 1. Physico-chemical examination of soil of experimental location for both years of sugarcane cultivation

Determination	2011-12	2012-13
Texture	Loam	Loam
Saturation (%)	34	36
pH	7.2	7.6
EC (dS m^{-1})	2.13	2.08
Organic matter (%)	0.83	0.96
Total N (g kg^{-1})	0.58	0.51
Available P (mg kg^{-1})	7.02	7.85
Available K (mg kg^{-1})	151	155

Notes. EC, electrical conductivity. N, nitrogen. P, phosphorous, whereas K, potash.

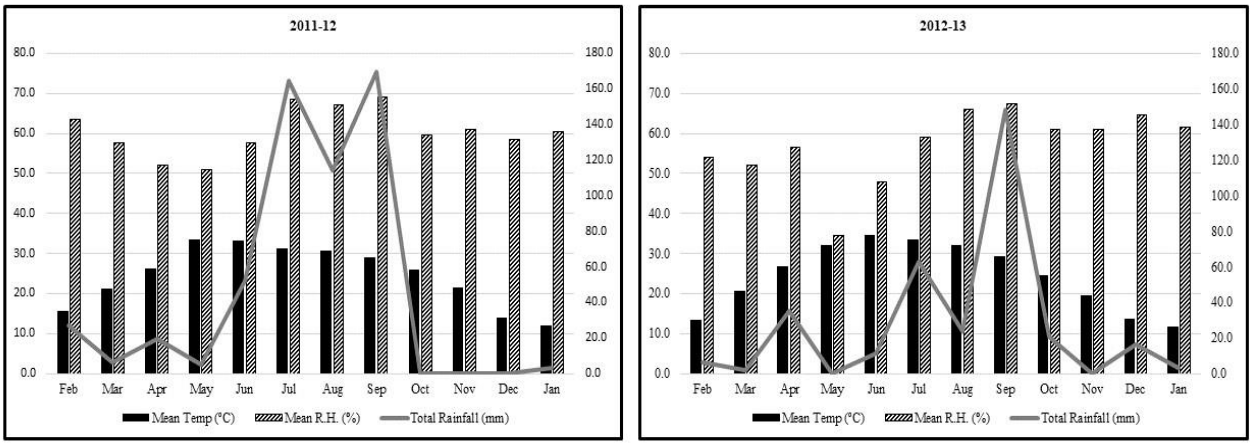


Figure 1. (a & b) Weather data during both crop seasons of sugarcane cultivation
Source: Observatory of Plant Physiology Section, Agronomic Research Institute-AARI, Faisalabad

Treatments and Design: Three sugarcane clones developed and released by SRI, Faisalabad *viz.* CPF 247, CPF 248 and CPF 246 were tested against cane setts stalling *viz.* fresh (check), 3 days stale cane setts, 6 days stale cane setts and 9 days stale cane setts. Replicated three times, the trial was laid out in RCBD under split plot arrangement keeping plot size of 12 m × 9.6 m. Sugarcane clones were kept in main plots whereas cane setts staling were placed in sub plots.

Experimental Material and Planting: The sugarcane seed of all three clones was prepared as per treatment plan. For this purpose, cane seed from nine months old healthy

plant crop was harvested at 3, 6 and 9 days before planting of experiment, respectively, trashed manually and placed under shade. Whereas, fresh seed was harvested and prepared at the time of planting. The whole experiment was planted in spring on 28 and 29 February, 2011 and 2012, respectively in each year at recommended 1.2 m apart dual row trench planting method. Recommended seeding rate of 50,000 TBS ha^{-1} was used and fertilizers were applied @ 168-112-112 NPK Kg ha^{-1}. All other Agronomic practices were applied according to recommendation and kept uniform for all the experimental units.

Data Collection of Biometric and Qualitative Traits: Data regarding germination percentage and tillers $plant^{-1}$ were recorded at 50 and 90 days after planting (DAP), respectively while millable canes, cane yield, CCS % and sugar yield were computed at final harvest. Standard procedures were adopted to record all the observations. Total germinant were counted from each experimental unit and were converted to germination percentage and similarly all tillers in each plot were counted to work out tiller $plant^{-1}$. During both years, the trials were harvested in the month of February of 2012 and 2013 after achieving crop age about more than 11 months. At harvesting, all the mature canes in each experimental unit were counted to work out millable canes ha^{-1}. Whole of each plot was harvested and canes were topped, stripped and weighed in Kg by using floor balance and then expressed as cane yield in tons of canes ha^{-1} (TCH). Ten randomly taken stripped canes from each experimental plot were taken to the Sugarcane Technology Laboratory, SRI, Faisalabad for quality analysis of cane juice. Canes were crushed with electric cane crusher (having about 70% extraction) for juice extraction and brix% were recorded with the help of hydrometer standardized at 20°C, Pol% were determined with Horn's dry lead sub-acetate method of sucrose analysis (Anonymous, 1970). Commercial Cane Sugar (CCS%) was calculated by employing formula:

$$CCS\% = 3P/2\{1-(F+5)/100\} - B/2\{1-(F+3)/100\}$$

(P stands for pol%, F for fibre% and B for Brix%)
Sugar yield was calculated by using the formula:
Sugar yield (CCS tons ha^{-1}) = CCS% / 100 × stripped cane yield

Statistical Analysis: The recorded data were statistically analyzed by using Fisher's analysis of variance technique (Freed, 1990) through Statistix 8.1 and least significant difference test was used to compare treatment means 5% level of probability (Steel *et al*., 1997). The Microsoft Excel and SigmaPlot were used for drawing graphs of weather data and cane & sugar yield, respectively.

Results

The perusal of table 2, 3 & 4 illustrated that germination percentage in sugarcane was not only significantly affected by clones and cane setts stalling period but their interaction was also found significant during both years. In 2011-12, the highest germination percentage was recorded in V_2S_1 when fresh cane setts of CPF 247 were used for planting whereas lowest germination percentage was recorded in V_3S_4 by planting 9 days old cane setts of CPF 246. The same trend was exhibited during 2012-13 and germination percentage was varied from 56.8 to 36.6% depending upon varietal and stalling period difference. The tillering potential of the varieties was also differed among them depending upon stalling period during the course of study. In 2011-12, more tillers $plant^{-1}$ was recorded in treatment combination of planting CPF 247 using fresh cane setts which was statistically at par with CPF 248 with fresh cane setts. Whereas, CPF 246 planted with 9 days stale cane setts showed lowest tillers $plant^{-1}$ during 1st year of study. A similar trend in tiller production was observed during second year of experimentation.

Millable canes ha^{-1} is a major yield contributing factor and it was found significantly affected by different sugarcane genotypes and cane setts stalling period and also their interactive effect was also significant during both years (Table 2, 3 & 4). Millable cane ha^{-1} was found maximum during both years when sugarcane variety CPF 247 was planted with fresh cane setts and it was closely followed by V_1S_1 (CPF 248 + fresh cane setts). However, lowest number of millable cane ha^{-1} were recorded in V_3S_4 (CPF 246 + 9 days stale cane setts) in each year (Table 4). The data indicated that sugarcane clones did not differed significantly with respect to final cane yield while it was significantly affected by cane sett stalling period. Whereas, the interactive effect of both factors was significant and highest cane yield was recorded in treatment V_2S_1 (CPF-247 + fresh cane setts) during both crop seasons but it was statistically at par with V_3S_1 (CPF-246 + fresh cane setts). On other hand, CPF 248 showed lowest cane yield when planted with 9 days old stale cane setts during both years of experimentation (Table 2, 3 & 4). The results also indicated strong dependence of cane yield on the freshness of cane setts used as seed (R^2= 0.99) during the course of study (Figure 2).

Sugar recovery is a percentage of sugar production in metric ton to the strip cane production per unit area and is generally considered as a genetic character of any sugarcane cultivar. So, the varietal difference showed a significant effect on sugar recovery but it was not affected significantly by stalling period of cane setts and their interaction during both years of study (Table 2, 3 & 4). Among varieties, maximum sugar recovery was recorded for CPF 246 for both crop seasons. Sugar yield is a bench mark to determine the profitability and productivity of any sugarcane production system. The sugarcane genotypes

and cane setts stalling singly as well as the interactive effect of both factors had significant effect on sugar yield during each year. The perusal of data presented in table 4 showed that highest sugar yield was produced by CPF 247 when planted by using fresh cane setts in 1st year and was found statistically at par with V_3S_1 (CPF 246 + fresh cane setts). During 2nd year of study, sugar yield was maximum in V_3S_1 (CPF 246 + fresh cane setts) but it was closely followed by other two varieties when planted fresh (V_1S_1 and V_2S_1). While, the lowest sugar yield was noted in CPF 248 when 9 days staled setts were used for planting (V_1S_4) during both years. The data (Fig. 3) also depicted the impact of cane sett staillness on overall sugar yield (R^2 = 0.98 & 0.99) during both years, respectively

Table 2. Biometric traits as influenced by sugarcane clones

Variety/clone (V)	Sprouting (%)	Tillers plant^{-1}	Millable canes (000 ha^{-1})	TCH	Sucrose contents (CCS%)	Sugar yield (CCS t ha^{-1})
2011-12						
CPF 248 (V_1)	47.2A	2.28AB	90.5A	81.5	13.6 B	11.0B
CPF 247 (V2)	47.8A	2.37A	91.5A	84.2	13.9AB	11.7A
CPF 246 (V3)	43.1B	2.10B	86.2B	82.1	14.2A	11.7A
LSD at 5%	**3.118**	**0.1963**	**3.875**	**N.S**	**0.5553**	**0.3166**
2012-13						
CPF 248 (V_1)	48.0A	2.43	90.8A	82.2	13.8B	11.3B
CPF 247 (V2)	48.2A	2.38	91.8A	85.1	13.5B	11.4B
CPF 246 (V3)	44.0B	2.2	87.3B	83.3	14.4A	11.8A
LSD at 5%	**2.967**	**n.s**	**2.539**	**n.s**	**0.2999**	**0.3943**

Means sharing different letters in a column, statistically differ from each other
Notes. TCH: tons of canes per hectare, CCS: commercial cane sugar, LSD: least significant difference

Table 3. Biometric traits as influenced by sugarcane seed (sett) stalling age

Seed/sett stalling (S)	Sprouting (%)	Tillers plant^{-1}	Millable canes (000 ha^{-1})	TCH	Sucrose contents (CCS%)	Sugar yield (CCS t ha^{-1})
2011-12						
Fresh (control)	54.0A	2.68A	102.7A	94.9A	13.9	13.2A
3 days old	49.6B	2.45B	95.1B	88.0B	14.1	12.4B
6 days old	43.2C	2.11C	84.2C	78.1C	13.7	10.7C
9 days old	37.4D	1.76D	75.6D	69.6D	13.9	9.6D
LSD at 5%	**1.886**	**0.1715**	**1.983**	**1.90**	**-**	**0.4451**
2012-13						
Fresh (control)	55.0A	2.72A	101.2A	94.5A	14.0	13.3A
3 days old	50.3B	2.49B	95.4B	87.5B	13.8	12.2B
6 days old	43.4C	2.17C	85.4C	80.2C	13.9	10.8C
9 days old	38.1D	1.98D	77.8D	71.7D	13.9	9.70D
LSD at 5%	**1.999**	**0.1486**	**2.337**	**2.203**	**-**	**0.5724**

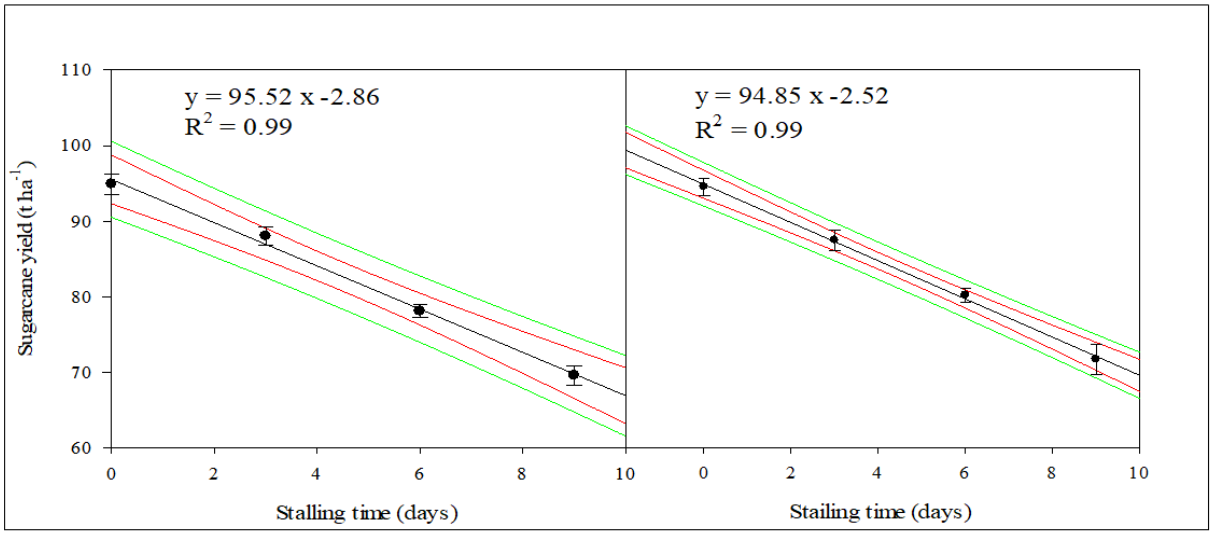
Means sharing different letters in a column, statistically differ from each other
Notes. TCH: tons of canes per hectare, CCS: commercial cane sugar, LSD: least significant difference

Table 4. Biometric traits as influenced by sugarcane clone and seed (sett) stalling

Interaction (V x S)	Sprouting (%)	Tillers plant^{-1}	Millable canes (000 ha^{-1})	TCH	Sucrose contents (CCS%)	Sugar yield (CCS t ha^{-1})
2011-12						
V_1S_1	55.3a	2.75a	103.3ab	94.0a	13.3	12.5b
V_1S_2	51.5b	2.55a	97.0c	86.8b	13.8	12.0b
V_1S_3	44.3c	2.20cd	86.1e	77.6cd	13.5	10.5cd
V_1S_4	37.8de	1.64f	75.5gh	67.9e	13.6	9.24e
V_2S_1	55.6a	2.76a	104.7a	96.5a	14.0	13.52a
V_2S_2	51.5b	2.54ab	97.2c	89.7b	14.1	12.6b
V_2S_3	45.1c	2.19cd	86.1e	80.0c	13.6	10.8c
V_2S_4	39.1d	1.98cd	77.8fg	70.7e	14.0	9.90de

V_3S_1	51.2b	2.53ab	99.9bc	94.4a	14.3	13.5a
V_3S_2	45.8c	2.25bc	91.2d	87.3b	14.4	12.6b
V_3S_3	40.1d	1.95de	80.3f	76.6e	14.2	10.9c
V_3S_4	35.4e	1.66ef	73.6h	70.2e	13.9	9.80de
LSD at 5%	**3.267**	**0.2971**	**3.435**	**3.29**	-	**0.771**
2012-13						
V_1S_1	55.7ab	2.77ab	99.8b	92.1bc	14.1	13.3ab
V_1S_2	52.5bc	2.59abc	95.8bc	85.7ef	13.7	11.9cd
V_1S_3	45.4d	2.21de	88.0d	79.7g	13.8	10.7ef
V_1S_4	38.4e	2.16def	79.8e	71.1h	13.5	9.15g
V_2S_1	56.8a	2.82a	104.2a	96.7a	13.4	12.9abc
V_2S_2	51.8c	2.54bc	97.5b	89.6cd	13.4	12.1c
V_2S_3	44.8d	2.26de	87.0d	82.1fg	13.4	10.72ef
V_2S_4	39.4e	1.92fg	78.6ef	71.8h	13.8	9.77fg
V_3S_1	52.6bc	2.58abc	99.8b	94.9ab	14.5	13.6a
V_3S_2	46.8d	2.35cd	93.1c	87.1de	14.3	12.5bc
V_3S_3	40.0e	2.03efg	81.2e	78.8g	14.4	11.0de
V_3S_4	36.6e	1.85g	75.0f	74.2h	14.4	10.2ef
LSD at 5%	**3.463**	**0.2602**	**4.047**	**3.816**	-	**0.9914**

Means sharing different letters in a column, statistically differ from each other
Notes. TCH: tons of canes per hectare, CCS: commercial cane sugar, LSD: least significant difference



a 2011-12 **b 2012-13**

Figure 2. (**a & b)** Variation in total final cane yield ha^{-1} to changing stalling time of sugarcane seed (billets/setts) during both crop seasons

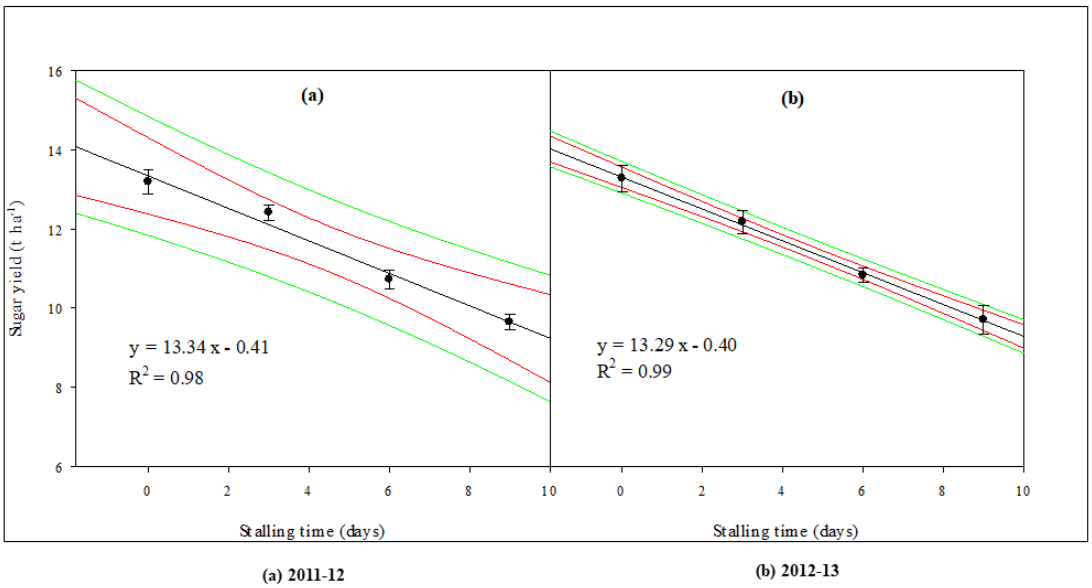


Figure 3. (**a & b)** Variation in total sugar produced per hectare to changing stalling time of sugarcane seed (billets/setts) during both crop seasons

Discussion

The findings of this study indicated that biometric traits varied both with sugarcane clones and length of cane seed stalling period, which suggested negative impact of time lag on seed quality mainly due to varietal differences and ability for resistance to loss in moisture, decrease in sucrose and increase in reducing sugars (Bhatia *et al.*, 2009). Germination depends heavily on viability of buds of cane seed. Difference in germination trend is mainly due to the difference in genetic potential of sugarcane cultivars and length of stalling cane setts. As CPF 247 has genetically better sprouting vigor than both of other cane cultivars. More germination in treatment V_2S_1 was also helped by better vigor of fresh seed setts having more moisture contents and other readily available food supplies in the form of simple sugar. Aslam et al. (2001) also observed similar trend is germination while comparing fresh and stale cane seed in sugarcane. The delay in harvest to planting could decrease buds viability of cane seed, thus, can cause failure or exhibit poor sprouting (Jain *et al.*, 2009). Shrivastava *et al*., (2008) also reported gradual and significant decrease in germination of stalled seed-setts of cane. Zhao *et al*., (2012) also reported sprouting in sugarcane genotypes was significantly lowered with stalled cane seed. Tillers plant^{-1} depends a lot on growth of seedlings that is negatively effected by increasing stalling period (Zhao *et al*., 2012). Therefore, more tillers plant^{-1} is attributed to good germination percentage which helped to produce healthier and better establishment of cane seedlings. Similar trend was observed by Shrivastava *et al*., (2008).

Better germination percentage and early establishment of seedlings and tillers plant^{-1} were responsible for higher number of millable of canes in sugarcane. As buds from stale cane tend to accumulate more phenols which may plausibly be associated with *in situ* toxicity due to secondary metabolites resulting in poor sprouting (Jain *et al.*, 2009). It was also observed that sugarcane clones which matures most of their produced tillers in millable canes would ensure better crop stand than others. Similar trend was observed in case of CPF 247 as it has the characteristic to mature its maximum tillers in millable canes. These results are in line with the findings of Jiang (2007) who reported comparable results. Increase in cane yield for treatment V_2 S_1 than others is due to genetic potential of CPF 247 and its improved growth and yield contributing factors due to better germination, seedling establishment, tillering and millable canes, achieved with freshness of cane billets (Hussain *at el*., 2011). Ali *et al*., (2002) investigated in a varietal trial that a variety with highest tillering capacity gave more cane yield when planted with fresh seed cane sett. Similar phenomenon was also explored by Deng *et al*., (2002).

The difference in sugar recovery is basically dependent upon genetic potential of sugarcane clones and a rapid decline in sugar contents during late crushing period in sugarcane crop was also reported by Singh and Solomon 2003). The variation in sugar yield is attributed to higher sugar contents for CPF 246 along with better cane yield due to freshness of cane billets. Genetically, the clone CPF 246 has better sugar contents than other genotypes. A similar trend in CCS (t ha^{-1}**)** was also revealed by (Atta *et al*., 1992) in his studies. The difference in bud viability, height of seedlings, number of sprouted setts and seedlings varied not only due to length of stalling period but also with sugarcane clones, thereby providing breeders an option to select sugarcane clones with better stalling-resistant ability for plant growth.

Conclusion

Increasing staleness of cane seed had negative effect on agronomic traits, cane and sugar yield of sugarcane. It is therefore suggested that cane seed should be fresh or with minimum time lag of less than 3 days for harvesting-planting to get better cane productivity owing to improved germination, tillering and ultimately their contribution towards final cane yield and qualitative characteristics.

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